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Report on Investigation of the REL Model 575-BC Loran Transmitter

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AUTHORIZATION

1. In accordance with authority contained in reference (a), Loran Transmitter 575-BC, Serial No. 6671, was subjected to tests to determine its suitability for use in the Naval service. This equipment was designed by the Radiation Laboratory, Massachusetts Institute of Technology and manufactured by the Radio Engineering Laboratories, Long Island City, N. Y. Additional references alluded to this report are listed as references (b) to (f), inclusive.

Ref: (a) BuShips ltr. Serial No. 495(926) of 11 Aug. 1943 to NRL.
(b) NRL ltr. C-S67-9/10(383) of 16 Sept. 1943 to BuShips concerning preliminary investigation of Model A-1 Transmitter Testing Oscilloscope.
(c) NRL ltr. C-S67-9/10(383) of 29 Sept. 1943 to BuShips concerning results of preliminary investigation of 575-BC Loran Transmitter.
(d) BuShips Spec. RE 13A 682B for Radio Pulse Transmitting Equipment.
(e) BuShips Spec. RE 13A 575C for tracings, manufacturing drawings and instruction books.
(f) BuShips conf. ltr. Serial 804(925B) of 16 Nov. 1943.

INTRODUCTORY

2. Where practicable, tests followed the same procedure as employed in testing standard Naval equipment. A general summary of pertinent recorded data is presented in the following paragraphs and tables. Recommendations for improvement and conclusions regarding general suitability of the apparatus are likewise presented.

3. Since only one timer was available during most of the test period, much of the data presented covers only the single pulsed condition, pulsing being accomplished at rate 6. Later, a second timer was made available and data presented in Appendix A were obtained for the double-pulsed operation.

4. Reference (b) contains information concerning the preliminary investigation of the Model A-1 Transmitting Testing Oscilloscope. Results of the preliminary investigation of the 575-BC Loran transmitter may be found by referring to reference (c).

PHYSICAL DESCRIPTION

5.

(a) The apparatus submitted for test consisted of the

following units:

(1) One Loran Model 575-BC Radio Frequency Unit, Serial No. 6671. (Plates 9 to 19, inclusive).

(2) One Loran Model 575-BC Power Supply Unit, Serial No. 6671. (Plates 20 to 29, inclusive).

(3) One Antenna Matching House and Unit, CG-LSR-631A. (Plate 8).

(4) One transmitter testing oscilloscope, Model A1, Serial No. 31, built by the Sylvania Electric Products Co. (Plates 30 to 34, inclusive).

In addition, the following units were employed to test the equipment but were not themselves under direct test:

(5) One Loran Timer and DuMont Timer Oscilloscope, Model B, Serial No. 13, built by the Cambridge Research Company.

(6) One line testing oscillator built by the Allen B. DuMont Laboratories.

A set of spare tubes and a complete set of necessary accessories, inclusing the BC-6 Signal Sampling Network Box and antenna sampling loop, were also received. Plate 7 shows a view of accessories supplied.

(b) The dimensions and weights of the various major units are shown in Table 1. Dimensions and weights are included with and without shipping crates. Table 1 also contains data on clearances recuired to open access doors and hang the shelf holding the monitoring oscilloscope. The attached plates illustrate the general construction of the equipment.

6. The two-unit cabinet for the equipment is made up of 12 gauge (0.109") steel and is entirely welded. No frame of any kind is incorporated and, as a result, the mechanical strength and rigidity of the cabinets are far less than those normally encountered in Naval equipments. Plates 10, 11, 12, 22 and 23 show the general construction and the use of welded 12 gauge metal straps to provide additional strength. Sixteen gauge (0.062") steel is used for access doors, shielding between units and other light applications. No provisions have been made either for bolting the equipment to a foundation or for bolting the units together. In view of the type of construction employed, certain advantages are realized in the way of accessibility by the omission of securing bolts. However, disadvantages also exist. Increased security during the shipment would be provided if the equipment

was firmly anchored within the shipping containers and, in certain installations, provision for securing the equipment to a foundation would be desirable. Plate 9 shows the electrical interconnection between the units consisting of the high voltage "tiller", modulator excitation and a 12 wire cable for handling miscellaneous power and control potentials. The two cabinets are bonded together with a 5-11/16" inter-cabinet ground strap with provision for running a cable to earth. Lifting eyes have not been provided as required by Par. 2-33 of reference (a). It is doubtful whether the present mechanical design is sufficiently strong to withstand the strain of lifting eyes. The flexibility of the present cabinet is such that when one side of the rectifier unit was raised about six inches with the other side resting on the deck, the access doors became jammed. The equipment in its present form is unwieldly to handle since lifting eyes are not provided. At least four men are required to lift the main units of the equipment. The base of the unit is so weak that the equipment may be dragged only on smooth surfaces without resultant damage. The base dimensions are in excess of those normally found in similar equipments and consequently the equipment does not fit rolling stock used to facilitate movement of heavy equipments in Naval Shore establishments. Power and timer cables enter the rectifier unit through holes in the rear and right side, respectively. Antenna and Oscilloscope Test Potentials enter the radio frequency unit through holes in the rear and left side, respectively. Rear access doors must be opened for servicing the exciter and radio frequency unit. All exterior and interior surfaces have been finished with a gray crackle lacquer.

7. The general construction of the radio frequency unit, which contains the oscillator, may be observed by referring to Plates 9 to 19, inclusive. Plate 15 shows the lower front view of the modulator-screen oscillator-grid voltage supply. Plate 18 shows an upper rear view of the modulator unit. It is recommended that these units be equipped with high quality jack and plug arrangements of a type similar to the Lapp Type BCO-49466 (Female) and CBO-49465 (Male) to facilitate rapid removal for servicing. To further improve the ease of removal of these units it is suggested that captive nuts be secured to the frame so that the units may be removed with a minimum of time.

8. Plates 20 to 29, inclusive illustrate the power supply unit housing the high voltage rectifier, two exciters and the control circuits. This unit is identical in physical dimensions to the radio frequency unit. Provisions have been made on the right side to hang a shelf to support the monitoring oscilloscope as shown in Plate 4. The BC-6 Signal Sampling Box (shown in Plate 7) is mounted on the rear edge of the oscilloscope shelf so that its output cable may be within easy reach of the oscilloscope input terminals. Ventilation of the rectifier unit is accomplished by the use of the eight-inch exhaust fan visible in Plate 23. Due to the shelf type of construction of the exciter unit, shown in

Plate 26, ventilation of the tubes is not considered adequate.

9. The physical construction of the transmitter monitoring oscilloscope may be observed by referring to Plates 30 to 34, inclusive. Oscilloscope controls used in normal operation, such as input switching, are not available for front panel operation. Considerable backlash was found in controls R-3 and R-6 which was due to the use of cloth inserted bakelite shafts attached to universal couplings of similar material. It is recommended that metal shafts be employed and that isolantite couplings be installed.

10. Plate 8 shows a view of the antenna matching house, the antenna matching unit and the antenna sampling loop. The construction of the antenna matching house is poor in that it is large for the purpose intended, and is not provided with a glass window for visual inspection or a hinged door for necessary access. Due to the peculiar antenna problems encountered during the Laboratory tests, which were largely a matter of location, no comment can be made about the electrical characteristics of the antenna matching unit. Paragraph 31 describes the antenna system employed at the Laboratory and the modification of the Antenna Coupling Unit. The use of cloth inserted bakelite in the Antenna Coupling Unit is undesirable in view of the continued exposure to the atmosphere and varying degrees of humidity. The coupling coils should be wound on ceramic forms. A standard transmission line fitting, similar to the one used in the Antenna Sampling Loop, should be employed on the Antenna Coupling Unit to facilitate attachment of the transmission line from the transmitter.

TUBE COMPLEMENT AND VACUUM TUBE OPERATING CONDITIONS

11. See Par. 2-17 of reference (d). The tube complement employed is listed in Table 2, both for the transmitter and the monitoring oscilloscope. It should be observed that the type 5W4, one in the oscilloscope and another in the exciter, is not an Army-Navy Preferred Tube. The same is true for two 5V4G's used as Mixer Diodes in the exciter unit. These tubes should be replaced by a single type of rectifier on the Army-Navy preferred list. Tests were conducted with 5R4GY's and 5Y3GT's in the above mentioned positions. No perceptible change could be observed in the operation of the equipment or in the output pulse shape. To simplify the spare tubes problem, it is suggested that four 5Y3GT's be substituted for the 5V4G's and the 5W4's. The use of 5R4GY's in the Mixer Diode positions allows about 1/4" between the top of the tube and the cabinet door, a condition which might contribute to tube breakage, hence proper precautions would be necessary to avoid damage. Changes in wiring are not required to permit the use of these tubes, although a change in tube clamp would be necessary. A complete set of spare tubes was provided for the transmitter and rectifier units although no spare tubes were supplied for the monitoring oscilloscope.

12. In numerous instances vacuum tubes in the equipment are operating at potentials exceeding maximum values established by the tube manufacturer and the Joint Army-Navy Specifications:

(a) The 2X2 rectifier, V7, is operating at 8.1 ma while maximum current has been set by specifications at 7.5 ma. V7 in both exciter units was replaced by a 3B24 resulting in somewhat higher output voltage. For some reason which was not immediately apparent, better "keying" action resulted. No circuit changes are required to replace the 2X2 with a 3B24.

(b) A potential difference of 1545 volts exists between cathode and plate of the 829's, V12 and V13 in the exciter. The specifications allow a maximum of 500 volts for the plates of the 829. A screen potential of 434 volts is used while the maximum permissible is 225 volts. It is suggested that equipments currently in production be supplied with the 3E29, an exactly equivalent tube designed for pulsed operation at high potentials. For future models it is suggested that consideration be given to the use of a 715A, or 715B tube, to reduce the number of tube types employed in a given equipment and to simplify circuit construction. Tests were conducted at the Laboratory with V12 and V13 replaced by a single 715A. Little effect was noted in output pulse shape or output. A separate filament transformer is required. More current is also drawn through V7.

13. It is evident that potentials in excess of those for which the type 98R Oscillator tubes were designed are being employed. Next to arc-overs to the grid flipper, arc-overs on the glass of the 98R between the grid and plate seemed to be the most frequent cause of disruptions in normal operation. After remaining idle in an atmosphere of high humidity, these tubes gave considerable difficulty. Under conditions of normal temperature and humidity little difficulty was experienced from this source provided the glass of the 98R was cleaned daily with carbon tetrachloride to remove particles of dirt and dust which has been deposited there by the forced ventilation from the fan. If possible, when designing new tubes for this application, a longer creepage distance over glass should be allowed between grid and plate.

14. In the transmitter monitoring oscilloscope, V6, V9, and V13 tubes are operating at potentials above specification limits. The screen-grid potential on V6, a type 6SJ7, is 207 volts, it should not exceed 140 volts. V9 and V13, type 6SJ7, have screen potentials of 153 volts, which also exceeds the specification maximum for this type tube.

15. The following observations were made on the location and mounting of vacuum tubes:

(a) All tubes mounted in a horizontal position have been provided with tube clamps.

(b) The plate pin connectors for the type 829 exciter tubes, V12 and V13, are connected to terminals located directly above and in line with the tube plate pins. Therefore it is necessary to force the tubes to one side when these connectors are attached or detached. To avoid danger of damage to the tubes it is recommended that the terminals be relocated on all new equipments.

(c) Connection to the type 98A oscillator tube grid posts can be made only with considerable difficulty, since the connection studs are located too close to the tube grid caps. To accommodate possible production variations in the length of the tube grid lead, it is recommended that the insulated strip to which the stud is secured be capable of adjustment and that means for clamping the strip in the correct position be provided.

(d) Tubes in the exciter operate at higher temperatures than normal. An exhaust fan is mounted in the top of the power supply unit but ventilation is impeded due to obstructions about the exciter tubes, which have been mounted on semi-enclosed shelves as shown in Plate 26.

(e) Provisions made for ventilation of the modulator tube, V14, are inadequate resulting in operation at temperatures higher than are desirable. The position and enclosure of this tube are illustrated in Plates 10 and 18.

CONTROL CIRCUITS AND RELAYS

16. To place the equipment in operation it is necessary to manipulate the following six controls, all of which are mounted on the operating panel of the Rectifier Unit: Line Switch, Stop-Start Switch, Low Power Filament Switch, Exciter High Voltage Switch, and Oscillator High Voltage Switch, after which the Rectifier High Voltage Variac is advanced until the Rectifier High Voltage Meter indicates the correct operating potential. It should be pointed out that the main line switch, SW-1, is provided with a thermal overload. A test at room temperature showed that the thermal overload tripped in 35 seconds with a 100 amp. load, and that 17 seconds were required before it could be reset. This switch is rated at 50 amps. The maximum current through the switch at 250 line volts single pulsing was found to be 13.2 amperes. Better protection would be afforded by the use of suitably rated line fuses or a compact combination line-switch and magnetic-overload. Normally, the oscillator filaments are shut down by use of the Oscillator Filament Switch, and the blower providing forced draft cooling of the oscillator tubes continues to operate for two minutes. However, if the operator shuts the equipment down by use of the main line switch, the power is

simultaneously removed from both tubes and blower, subjecting the tubes to unnecessary strains and danger of damage. Since the location of the line switch makes this undesirable operation probable, particularly when a hasty shut-down is required, it is suggested that a warning nameplate be provided or that the switch be placed on the relay panel.

17. Low Power Filament Switch, M1, is thrown second in the sequence. Then the momentary depression of the Master Control Switch start button operates the starting contactor, RE1, which starts time delay relay, RE2TD; connects the low power filaments; gives pilot light indication; locks in Blower Motor relay RE3 and prevents energy from being supplied at this time to relay RE4TD, the 2 minute time delay which keeps potential supplied to the blower motor after the starting contactor and switch M2 are open. When Oscillator Filament Switch, M2 is closed, power is supplied to the oscillator filaments provided fuses are intact and the sail switch is closed. The sail switch, operated by a vane in the blower air duct, shuts down the equipment if the air supply fails.

18. After time delay relay RE2TD has operated, M3, the Exciter High Voltage Switch, may be closed to apply power to the exciter, and to remove the short circuit from the high voltage filter condenser by energizing relay RE5. If Manual switch, M4 (Rectifier High Voltage), is now closed, auxiliary contacts of relay RE5 energize the 30-second time delay relay RE6TD which operates relay RE7. RE7 then locks in and opens relay RE6TD which, in turn, releases contactor RE8 and applies voltage to the high voltage rectifier. The voltages to the plate transformers of the rectifier are applied through a variac which is mechanically set so that the minimum voltage from the high voltage transformer results in approximately 5000 volts output from the rectifier. The modulator screen potential is applied at the same time that the voltage is applied to the variac input.

19. To stop the equipment it is necessary to momentarily depress the stop button, thereby releasing all contactors except relay RE3 which remains locked in. The release of relay RE-1 starts the two-minute delay relay, RE4TD which opens relay RE3 and cuts off the blower circuit two minutes after all power has been removed from the oscillator tubes. This action permits the oscillator tubes to be cooled, preventing the possibility of tube damage.

20. In the event of an overload, a d-c overload disconnects all power from the high voltage rectifier by the action of relay RE11, the contacts of which are connected in series with manual switch M4. The d-c overload relay is instantaneously restored and the operation of relays RE6TD, RE7, RE8, RE9TD and RE10 will automatically occur as described above, provided normal conditions exist after the overload. If the d-c overload is tripped, the recycling time is about 1 second. Data on currents through relay

R11, may be found by referring to Table 3.

21. To improve the control system it is recommended:

(a) That the thermal overload for line protection be replaced by fuses or a suitable compact combination line-switch and magnetic-overload.

(b) That the d-c overload relay, RE11, be replaced by a more suitable type. The minimum setting at which the overload will open was found to be 43 ma. The overload was set to open at 56 ma as received from the manufacturer, while a current of only 11.8 ma was found to be flowing with 17.5 KV Oscillator plate potential, single pulsed. Attention is invited to Par. 2-10(3) of reference (d) which requires overload relays to open at 25% above the normal full load current value. It is suggested that a relay be provided that is capable of adjustment either to 25% above the full load current value, single pulsed, or 25% above the full load load current when double pulsing is employed. These two points should be clearly marked on the relay when the equipment is shipped and the equipment labeled to indicate whether the relay is set for single or double-pulse operation when it leaves the factory.

(c) That means be provided to prevent possible damage to the modulator cathode meter and the oscillator grid meter under conditions of erratic operation. It was noted that at times for no apparent reason that if the modulator is not receiving excitation and plate voltage is applied to the oscillator, the modulator draws high current Modulator bias voltages measured normal. When this condition occurs, the modulator cathode meter is driven off scale and the oscillator grid meter gives erratic indications. This seemed to occur only at such times when the equipment was started from a cold condition. However, it also occurs if the modulator bias supply fails and the rectifier overload relay is not set to an absolute minimum permitting control circuit recycling. It is believed that this condition will be connected by the application of the recommendation in the previous paragraph.

(d) That the Oscillator High Voltage Pilot Lamp Indicator, PL-2, be connected in parallel with the coil of relay RE10 so that the lamp does not light until full voltage is being applied to the rectifier and the variac is ready for adjustment by the operator. It was found during the course of the tests that the lighting of Indicator PL-2 conditions the operator to such an extent that he instinctively begins advancing the variac, thereby raising the voltage applied to the rectifier. After 5 seconds the action of realy RE9TD places full power on the rectifier with the result that if the variac has already been advanced appre-

ciably, a flash-over or overload occurs. It is believed that the lighting of Indicator PL-2 should serve as an indication to the operator to begin advancing the variac.

(e) That corrective action be taken in regard to overloaded sail switch ASW1, Minneapolis-Honeywell Type S43A1X, equipped with a Minneapolis-Honeywell 5-ampere C-645-3 mercury-switch contactor. Under normal operating conditions this contactor carries 9.2 amperes at 115 volts. During the course of the tests insulation on the wires to the mercury switch became charred due to excessive currents. It is suggested that the Type S43A1X switch be fitted with a Minneapolis-Honeywell H-113-3, 15-ampere, mercury-switch contactor. Connections to the sail switch and to the quarter horse-power blower motor BL1 are made with lamp cord. This type of wiring is not considered desirable in either application and the wire to the switch is overloaded.

INDICATOR LAMPS AND DIALS

22. Two indicator lamps, not of a Navy approved type, have been provided. A green lamp indicates that low power filaments are on while a red lamp indicates the application of Oscillator High Voltage potential. Par. 2-35 and 3-35 of reference (d) describe the Navy types and circuit applications which are preferred. The following indicator lamps are suggested:

(a) Low Power Filaments - clear or white.

(b) Oscillator Filaments - clear or white.

(c) Exciter High Voltage - red.

(d) Oscillator High Voltage - red.

A discussion of the circuit application of the oscillator high voltage indicator lamp is contained in Par. 21 (d) of this report. The indicator lamps should be arranged in a horizontal line across the operating panel of the Rectifier Unit.

23. The grid and plate tuning controls employed in the equipment are unsatisfactory. Controls for the frequency determining circuits have not been provided with stops, as required by Par. 2-30(4) of reference (d), to limit the degree of motion of the control to that within which the control is calibrated. Additionally, these controls should be capable of movement through only 90 degrees. The dial now turns through 360 degrees with the calibration applied for 180 degrees with 100 divisions. From 0 to 50 a decrease in frequency results with an increase in dial reading, whereas, from 50 to 100 the frequency increases with increasing dial reading. Taper pins have not been provided as required by Par. 2-30(3) of reference

(d). Markings have been provided to indicate the function of each control but letter designations have not been employed as required by Par. 3-29 of reference (d). Par. 3-32 of reference (d) requires the use of a suitable friction-type locking device to prevent the accidental movement of variable tuning controls. Locks have not been provided.

METERS

24. Metering of circuits is accomplished by the use of nine meters, five in the radio frequency unit, three in the power supply unit, and one in the antenna coupling unit. In the radio frequency unit, reading from left to right in Plate 14, they are:

(a) Oscillator filament volts, Triplett Model 377-A, 0-150 volts, ac.

(b) Modulator cathode current, Triplett Model 327-A, 0-25 ma, dc.

(c) Oscillator grid current, Triplett Model 327-A, 0-10 ma, dc.

(d) Radio Frequency output current, Triplett Model 347-A, 0-1 amp., rf, provided with an external thermocouple so that meter readings must be multiplied by three to obtain the indicated value.

(e) Oscillator cathode current, Triplett Model 327-A, 0-25 ma, dc.

The power supply unit employs three meters reading from left to right in Plate 24 are:

(f) Rectifier filament volts, Triplett Model 377-A, 0-150 volts, ac.

(g) Oscillator filament tube-hour meter, Westinghouse Type RH4, style 1205873, 120-volts, 60-cycles.

(h) Rectifier high voltage, Triplett Model 327-A, 0-30 kv, dc, for use only with a 30 Meg. External Multiplier Resistor.

The antenna coupling unit in the antenna matching house, shown in Plate 8, has been provided with:

(i) A Weston, 0-5 amp. Radio Frequency Ammeter, Model 425.

25. Of the meters employed in the equipment only the West-

inghouse and Weston meters are Navy standard meters. During the course of the Laboratory tests, difficulty was encountered with three of the Triplett meters. The Oscillator Filament Voltmeter failed at normal room temperature under apparently normal conditions. Upon removal and disassembly, it was discovered that the mounting pivots were too tight. This condition was corrected and no further difficulty was experienced with the meter. During the course of temperature tests, it was observed that sticking occurred in the Rectifier Filament Voltmeter as soon as the temperature reached 40°C. Apparently, the temperature rise caused an expansion of the pivots. Under conditions of normal room temperature, difficulty was experienced with the Oscillator Grid Current meter sticking near the zero position. It is suggested that only Navy approved type meters be employed.

26. The meters are not individually removable from the front panel with the present method of mounting. Par. 2-25(2) of reference (d) requires that all meters, except the r-f ammeter, be easily removed through the front panel. Meters have been equipped with by-pass units to obviate the possibility of damage by r-f current.

27. The Oscillator Grid Meter eventually failed because of a number of severe arc-overs between grid and plate over the glass of the oscillator tubes. These arcs result in severe transients sufficiently strong to overload the Grid Meter. Proper steps should be taken to eliminate this difficulty.

FREQUENCY MEASUREMENT METHOD

28. During the course of the tests it became apparent that the Crystal Oscillator Frequency Adjusting Device ("Cofad") method of frequency determination is unsatisfactory and confusing. It was determined by a series of tests that the average inexperienced operator could set the transmitter within ± 20 kc by the "Cofad" method unless he had been carefully instructed in its intricacies and peculiarities. When the "Cofad" in the transmitter monitoring oscilloscope is turned on by means of a front panel switch, its output is made to beat with the transmitted signal as received by the diode monitor. The pattern on the oscilloscope represents the beat frequency between the continuous wave pattern derived from the "Cofad" and the normal radio frequency pulse pattern. When the transmitter is considerably off frequency, the pulse will exhibit a very uneven top. As the transmitter is tuned to approach the proper operating frequency, the modulation of the pulse pattern gradually disappears, leaving a resultant pattern "breathing" in a vertical direction. Immediately prior to this "breathing" action the pulse pattern "pitches" fore and aft. The "breathing" and "pitching" motions react on each other so that the total pattern is complex. A factor which affects the "breathing near the

correct frequency is beating of the repetition rate frequency due to the Timer and the beat due to the "Cofad". In view of these complex interactions, it is suggested that the "Cofad" be removed from the equipment to eliminate confusion and errors.

29. Let it be assumed for purposes of discussion that the pulse pattern is perfectly rectangular in form and of 40 microseconds duration. If a 20 kc beat frequency modulates the pulse, it is apparent that each cycle of the beat frequency is of 50 microseconds duration, a fact which does not permit the presentation of a complete cycle of the beat frequency. This fact accounts for the "pitching" described in the previous paragraph As zero beat is approached, the length of each cycle of the beat frequency becomes so great that it cannot be presented as a modulation of the pulse. This condition is further complicated by the presence of a beat frequency between the repetition rate of the monitoring oscilloscope and the low frequency beat due to the "Cofad". Methods of measuring radio frequency variations in pulse transmitters sufficiently accurate to measure the minute variations permitted by Par. 3-26(3)(a) of reference (d) have not been devised by the Laboratory. A realization of the difficulty of visual presentation for this purpose can be had by considering a few calculations. Still assuming that a rectangular 40 microsecond pulse is being employed at a carrier frequency of 1850 kcs., each pulse of radio frequency consists of 74 cycles of radio frequency. A 0.006% change in carrier frequency corresponds to a 0.0044 cycle change per pulse. It should also be remembered that the "Cofad" method of frequency indicates absolute frequency at the frequency of the crystal oscillator. In itself it is not an indicator of whether the operating frequency is above or below the correct frequency. The latter information must be obtained by tuning above and below the breathing point and then referring to the transmitter plate tuning calibration, the numbering of which is highly confusing as described in Par. 23 above.

30. Due to these difficulties in frequency measurement, all measurements of frequency recorded in this report were made with a General Radio Type 224 Radio Frequency Wavemeter. Since the wavemeter method provides improved accuracy, it is recommended that a precision wavemeter be incorporated as an integral part of the equipment. This wavemeter should cover the range of 1700 to 2000 kcs. with an end tolerance of 3% at the high and low frequency ends of this range. Suitable precautions should be taken to insure freedom from the effects of temperature and humidity on the accuracy of the readings. A vernier dial, indicating meter and calibration chart should be provided on the front panel of the radio-frequency unit. The calibration of the wavemeter should be made with the wavemeter rigidly fixed in position in the transmitter to avoid coupling inaccuracies. A crystal controlled oscillator may also be incorporated for periodic wavemeter calibration checks.

ADJUSTMENT OF THE ANTENNA TUNING UNIT AND ITS EFFECTS ON TRANSMITTER OPERATION

31. Initially, considerable difficulty was experienced in attempting to match an antenna system to the transmitter. The steel antenna towers at the Laboratory, near the Transmitter Building, are 120 feet high and so spaced as to cause considerable reaction with the Loran antenna system. During the first attempt, the antenna matching house was placed on the ground but the 40 foot high Transmitter Building apparently shielded the vertical antenna to such an extent that it was difficult to achieve a resistive antenna. The antenna matching house was then moved to the roof of the Transmitter Building as shown in Plate 8. A 120-foot long 3/8 inch phosphor bronze cable was suspended about 30 degrees from the vertical. Measurement with a General Radio Impedance Bridge indicated 48-j27 ohms impedance at 1850 kc. The Transmitter "squegged" on all of the variable taps of antenna matching unit due to the failure of the transmitter and antenna system to "track" in pulse rise and decay times. The transmission-line parallel terminating impedance was then removed and the antenna characteristics were measured at the low end of the series inductance of the antenna matching unit with the following results at 1850 kilocycles.

Impedance measured at the number 1 tap of the series inductance - 64+j27 ohms.

Impedance measured at the number 2 tap of the series inductance - 62+j23 ohms.

Impedance measured at the number 3 tap of the series inductance - 62+j18 ohms.

Impedance measured at the number 4 tap of the series inductance - 62+j10 ohms.

Impedance measured at the number 5 tap of the series inductance - 62+j5 ohms.

Impedance measured at the number 6 tap of the series inductance - 62+j0 ohms.

Impedance measured at the number 9 tap of the series inductance - 59-j13 ohms.

A 60-foot length of 50-ohm transmission line was then connected to tap number 4 with the transmission-line parallel terminating impedance disconnected. With this arrangement, an impedance of 35+j8 ohms was obtained at the transmitter end of the transmission line. The measured impedance of the dummy load was found to be 41+j13 ohms at 1850 kilocycles. The transmitter seemed to operate satisfactorily with this antenna since the transmitter meter readings did not vary appreciably when switch-

ing from the dummy to the real antenna. The antenna described above was used to obtain the data recorded in Plates 1, 2, and 3, wherein information on field strengths with real and dummy antennas plus information on field strengths of side bands is presented. Field strengths of harmonic frequencies are recorded in Table 7.

32. Operation of the Antenna Sampling Loop and the BC-6 Antenna Sampling Box seemed to be satisfactory after the system was placed in operation, but a defect in the construction of the sampling box caused considerable difficulty until it was discovered. Plate 7 shows a view of the BC-6 Sampling Box and Plate 8 shows the Antenna Sampling Loop mounted in the right side of the Antenna Coupling House. Coil L6 in the Sampling Box is supported by two metal bushings and was poorly assembled. As a result, the metal bushing was making contact with the last turn of the coil and consequently, the sampling potential was shorted to ground.

EFFECTS OF VOLTAGE VARIATIONS

33. Data on voltage variations are presented in Table 6. From these data it is apparent that the frequency stability is extremely susceptible to variations in line voltage. Tests were then conducted to ascertain the circuits in which voltage variations caused the greatest frequency variation. By referring to the data it may be seen that changes in oscillator filament potential seem to be the source of most of the frequency variation. Data on the frequency variation caused by changes in the oscillator plate voltage, with other potentials held constant, are also shown in Table 6. It should be noted that when the oscillator filament potential is held constant, the frequency variations caused by line voltage changes are so small as to fall within the instrument error of the General Radio Type 224 Radio Frequency Wavemeter.

34. An investigation of the improvement effected by maintaining constant oscillator filament potential was made by supplying the primary of the oscillator filament transformers with Thordarson Automatic Voltage Regulating Transformers (T-9V32) rated at 500 va. One regulating transformer was employed for each filament transformer. A +10% to -10% voltage change in the primary voltage applied to this transformer results in a 0.7 volt change in voltage applied to the primary of the Oscillator Filament Transformer. Tests indicated that under full load operation the regulating transformer output voltage varies 1.5 volts when the primary voltage varies from 95 to 130 volts. The 115 volt output connection was used. The use of a Sola Type 4, Cat. No. 3005, 500 va voltage regulating transformer was also attempted, but it failed to regulate the voltage to the filament transformer. Both filament transformers were then regulated satisfactorily by a Sola Type 4, Cat. No. 3006, 2000 va regulat-

ing transformer. It should be remembered that certain types of automatic voltage-regulating transformers are extremely critical to variations in line frequency. Despite this fact, a real improvement in operation of the equipment results if suitable Oscillator Filament Transformer regulating transformers are installed. Their incorporation in the equipment is recommended. Consideration should also be given to the possibility of an oscillator filament transformer built on the automatic voltage regulator transformer type of construction.

35. Another effect of regulating the oscillator filament potential was to minimize the frequency of arc-overs and increase the ability of the equipment to operate at higher plate potentials. Without regulation of the oscillator filament potentials it was found that approximately 19 5 kv was the highest plate potential at which the equipment would operate without constant arc-overs. However, when the oscillator filament potential was regulated, the frequency of arc-overs was markedly reduced. Consequently, the oscillator plate potential could be raised. The transmitter was operated with oscillator filament potential regulation at a plate potential of 22 kv for a period of 90 minutes during which only one arc-over occurred. The Thordarson Automatic Voltage Regulating Transformers (T-9V32) were operated at full load for numerous periods of eight hours with both 95 and 130 input volts. No overheating developed during these periods of operations.

EFFECTS OF TEMPERATURE AND HUMIDITY

36. The transmitter testing oscilloscope was subjected to temperature and humidity tests simultaneously with the transmitter. The pulse timing equipment was not subjected to temperature and humidity tests. A General Radio Type 224 Wavemeter was used for frequency measurement while the output pulse shapes were continuously monitored on a Fada LRN-1 receiver, the DuMont "B" timer monitor and the transmitter test oscilloscope. Before beginning each test, the LRN-1 receiver and the timer receiver were carefully tuned to the frequency and allowed to remain on that frequency for the duration of the test. Changes in frequency due to temperature and humidity had no appreciable effect on pulse shapes as observed on the monitors. In examining the recorded data, it should be remembered that small changes in line voltage occurred which had a consequent effect on frequency variation. Due to the lack of a second timer, the equipment was single pulsed on all tests at rate six.

37. Pertinent data on the effects of variations in ambient temperature are recorded in Table 8 During the operation at 50°C several cubic centimeters of compound leaked from condenser C14, which is mounted horizontally in the equipment. Attention is directed to paragraph 2-14 of ref (d) stating that no unit of this equipment shall contain compound which will soften

and flow at temperatures below 75°C unless contained in such a manner that the compound will not flow from the container when the equipment is in service use. Since condensers C14 and C60 are mounted horizontally, it is believed that this condition might be corrected by mounting these condensers in a vertical position. Steps should be taken to insure that a satisfactory compound has been used in these condensers.

38. Data on transmitter performance during variations in humidity are recorded in Table 9. The equipment operated satisfactorily during the variation of humidity after which the temperature was dropped from 40°C, 30% relative humidity, to -11°C in a half hour's time. No malfunctioning was observed. The transmitter was then shut down and allowed to remain idle for a period of two hours at -15°C When an attempt was made to resume operation, it was found that relay RE2TD had become so sluggish, as was relay RE5, resulting in the dangerous condition of interlock failure so that the doors could be opened without the high voltage being interrupted. The relay actuating the condenser shorting bar opened when power was applied but failed to drop when power was removed resulting in another dangerous condition since this leaves condenser C14 in a charged condition.

39. Subjection to a second high humidity test resulted in the operation recorded in Table 10. The equipment was allowed to remain idle for two hours at a temperature of 40°C and 95% relative humidity. When an attempt was made to start the equipment, it failed to operate properly because of corona between inductors L4 and L5. The corona pierced the insulation on L4 and ended on the turns of L5. Coil L4 was replaced and no further difficulty was experienced. However, it is recommended that the present bakelite coil forms be replaced by ceramic forms. Considerable corona was also noted around the terminals of transformer T4 as well as from the leads which connect the various "pies" of the secondary of T4. Severe corona was in evidence around the rectifier filament leads of transformers T1, T2, and T3. These leads should be isolated from each other and from metallic objects. Severe corona occurred between the metal end plates and the insulation on condensers C3, C4, and C14. These condensers have a small air space between a metal end ring and the insulation. It is believed that corona could be eliminated by filling these small spaces with some solid material meeting the requirements of Par. 2-14 of ref (c) that this compound shall not flow above 75°C or crack at temperatures below -32°C. Approximately five minutes were required for persistent arcing between grid and plate on the glass of the oscillator tubes to reach a minimum. Moisture which had collected on the oscillator tubes while the equipment was idle was dissipated by heat from the tube and the forced ventilation of the fan. At least an additional fifteen minutes passed before this drying process was sufficient to stop corona and allow the application of 12 kv plate potential. During these fifteen minutes the maximum potential which could be employed was about 12 kv.

This was due to the existence of corona and the fact that the high voltage voltmeter multiplier had become saturated with moisture, thereby causing the meter to read about 25 kv when it was evident from the position of the high voltage variac control and the tube currents that only about 12 kv were being applied to the oscillator plates. An additional thirty minutes of operation was required before the transmitter could be operated at full power, 17.5 kv plate potential, with arc-overs becoming less frequent than one arc-over every few minutes. After one and one half hours of operation the equipment was restored to normal operating condition.

40. The monitoring oscilloscope was subjected to high humidity for two hours with the equipment idle. When energized, it was observed that the monitoring oscilloscope operated with a higher beam intensity than originally. This condition seemed to rectify itself after about fifteen minutes of operation. The equipment was operated for a period of three hours after subjection to high humidity. After remaining idle overnight, the test chamber conditions gradually settled down to 20°C and 50% relative humidity by the following morning. The equipment was then started and functioned normally during a half-hour test period.

41. Following the temperature and humidity tests, which consumed four days, the following was observed.

(a) Corrosion covered the entire chassis of the monitoring oscilloscope.

(b) Rust was present on the container for the fibre glass in the air filters.

(c) The spot employed to attach the test condenser to the oscillator frame unit became badly tarnished. This spot has had the paint removed so that the test condenser may make a low resistance contact with the oscillator frame.

(d) Rust appeared in spots on transformers, T1, T2, T3, T4, and T7.

(e) Corrosion over the entire rear chassis of the exciter unit

(f) Mounting straps of C30 and C31 exhibited rust.

(g) Rust appeared around the cabinet lifting handles where paint had been scratched by the action of the handles.

(h) Rusting of screws and laminations of RE1, RE3, RE10, RE7, and RE8 was observed.

Attention is directed to par. 2-6 of ref (d) requiring that all items entering into the equipment construction shall be resistant to the corrosive action of a moist sea atmosphere or be suitably

protected therefrom.

42. Attention is directed to the quality of wire employed in wiring the exciter unit. An ordinary cotton covered tape is in use. A test showed that this wire is highly inflammable, leaving only white ash after being burned. It is also particularly susceptible to mutilation by fungus if subjected to humid tropical conditions.

43. In the event that difficulties persist from corona and voltage flashovers in connection with the high voltage rectifier, the possibility of employing oil immersed construction should be given consideration. High voltage units for x-ray applications are available in which all high potential parts, including the rectifier tubes, are completely immersed in oil. This type of construction largely eliminates corona and flashover but is accompanied by certain undesirable characteristics. It is practically impossible to prevent oil seepage. Oil must be maintained free from dirt and moisture and in sealed or unventilated equipment danger from explosions exists in the event the oil is subjected to an arc.

44. TRANSMITTER TESTING OSCILLOSCOPE

While ref (a) did not specifically authorize tests of the transmitter testing oscilloscope, its use was required for test of the transmitting equipment. During the course of transmitter tests certain limitations of the testing oscilloscope became apparent. The "Cofad", an integral part of the monitoring oscilloscope, has been discussed in par. 28, 29, and 30 above. Defects and recommendations concerning the monitoring oscilloscope are recorded in par. 53 below. Constructional details may be observed by reference to Plates 30 to 34, inclusive. It is recommended that a more suitable design of oscilloscope be provided with future models. Several types of servo-oscilloscopes which provide considerably more stability and satisfactory performance are available

45. INSTRUCTION BOOKS

Instruction Book No. 1 serves as a manual for the Transmitter Testing Oscilloscope, the BC-6 Signal Sampling Network Box, and the Sampling Loop for installation in the Transmitting Antenna Coupling House. This book is believed to be, on the whole, quite satisfactory. Copy No. 140 was supplied to the Naval Research Laboratory. The second instruction book supplied to the Laboratory was Copy No. 65D covering Instruction, Operating and Maintenance for REL Cat. No. 575-BC Loran Transmitters. This instruction book includes numerous addenda sheets, etc., so that it provides more of a history of Loran transmitters, particularly on the subject of antenna coupling methods and devices, than maintenance information. It is suggested that this instruction book be rewritten so as to supply complete technical information for operating and

maintenance personnel. Attention is invited to ref (a) pertaining to instruction books. Specific suggestions include:

(a) The expansion of exciter testing data, including techniques, coupling condenser values for the various circuits, and better interpretation of patterns obtained.

(b) Pictures in the instruction book show exciter No. 1 with only one 829 in place, thereby leaving the impression that operation is intended with only one tube.

(c) Photographs of the antenna matching house and the antenna matching house unit have not been provided. Details on these units are extremely limited.

(d) Instructions should be given to clean the oscillator tube daily with carbon tetrachloride to minimize the possibilities of arc-over. Frequent cleaning of the air ducts in the plates of the oscillator tubes is suggested. The importance of cleaning all components carrying high voltage, such as condensers and all insulators, should be stressed.

(e) The action of control circuits should be clarified by the use of a progressive block diagram showing the secuence and function of each switch and relay.

46. SUMMARY OF DEFECTS AND RECOMMENDATIONS, TRANSMITTING EQUIPMENT MODEL 575-BC.

In the following paragraphs items which do not conform with general Navy practice or which fail to comply with good engineering standards or practice have been classified under appropriate headings.

47. Method of Shipment.

(a) The two major units of the transmitter were packed in wooden crates with about one inch of corrugated cardboard separating the cabinet from the box. No bracing was employed and the frames were not bolted to the crates. This method of packing is not considered to afford sufficient protection, since the unit is not firmly restrained from moving within the crate. Additionally, any blow sufficient to break one of the boards comprising the crate is almost certain to damage the equipment. Such broken boards have been noted frequently on crated transmitters which have been subjected only to domestic shipment in transit from the manufacturer to the Laboratory.

(b) Access door keys should be fastened to their respective doors to facilitate removal of the units from their crates. Unlike shipboard transmitters, the 575-BC cabinets have no hand rails or other protrusions which may be grasped in removing the units. Access doors must be opened to obtain a grip on the frame.

(c) Oil was not removed from relay dash pots when the equipment was shipped and, as a consequence, oil had dripped over the lower front interior of the rectifier unit.

(d) The armature of relay RE-5 was tied down for shipment but no other relays were protected in this manner.

(e) All pilot and meter lights were not removed for shipment so that upon arrival at the Laboratory they were quite loose in their sockets. It is conceivable that they could be damaged by being shaken from their sockets.

(f) The ceramic cap to tube V14, modulator tube, was not wrapped and secured for protection during shipment.

(g) Although C13 was substantially braced in the equipment received at the Laboratory, the wood bracing is held in position by being cut to a snug, driving fit in the cabinet. Unless considerable accuracy in fitting the bracing is maintained the brace may slip. Since C13 has appreciable mass it could cause considerable damage to the equipment if it were to be torn from its mountings during transit.

48. Installation Instructions.

(a) The instruction sheets covering assembly of the transmitter which were attached to the front of the transmitter unit, were found to list the various steps in the wrong order. Although the correct instructions were contained in the instruction book, it is considered desirable to furnish revised installation instruction sheets with the transmitter.

(b) Parts to be assembled in the transmitter were not adequately labeled. A tag, having the same identifying name as employed in the installation instructions, should be affixed to each unit to facilitate assembly.

(c) A tag should be attached to the front panel of the rectifier and another to terminals A and B stating the line voltage to be applied to the auto-transformer as it is connected when shipped from the factory.

(d) The instructions for assembly and installation are not sufficiently complete and require expansion. No information regarding the use of Eimac capacitors was included. Directions for centering the grid tuning-loop were not furnished. Directions for the use of the servicing condenser with regard to the exciter and radio frequency unit were scanty. Directions should include the value of the capacitor to be used as well as the point of attachment together with a picture of the type of pattern to be observed on the testing oscilloscope if the equipment is working correctly.

(e) The instruction book gives the voltages to which the oscillator and rectifier filaments should be set but the values given were found to be incorrect. This difficulty may, in a large measure, be due to the use of voltmeters across the primary of the filament transformers to indicate the voltage. In this manner the production variations of the transformer may add to the meter error to produce considerable inaccuracy. The use of instrument transformers or the location of the meters in the high potential, secondary circuit of the filament transformers is considered necessary.

49. Adequacy of Marking.

(a) Fuse positions are not marked with the rating of the fuses required.

(b) Tube positions are marked only with the circuit symbol numbers. The type number of the tube required should be stamped adjacent to each socket. Several tube symbol numbers were upside down and others were carelessly stamped and difficult to read.

(c) The chart of typical meter readings on the front panel should read E_f Oscillator and E_f Rectifier.

(d) The main power switch has no nameplate to warn against operating this switch to shut off the oscillator filaments and blower motor simultaneously. It is considered desirable to place the line switch on the control panel so that the door must be opened to operate the switch. This will discourage operators from throwing the line switch immediately if trouble develops in the equipment. A suitable warning plate should also be affixed.

(e) Leads to the main auto-transformer are labelled with scotch tape. Permanent markings should be substituted.

(f) The outlet on the right side of the rectifier cabinet should be marked 110 V, ac.

(g) The main auto-transformer is not provided with a nameplate showing the connections for various voltages.

50. Installation Difficulties.

(a) Rectifier tube cap connectors are so arranged that they may be connected to the incorrect tubes.

(b) The high-voltage tiller rope connecting the transmitter to the rectifier is too long and may be grounded accidentally. In eliminating this difficulty, it is suggested that the transmitter and rectifier cabinets be bolted together to afford the minimum, fixed distance for the interconnection and to prevent

accidental short circuits which might otherwise result if any small metal objects were dropped between the units It is suggested that the tiller rope connection be shortened.

(c) Leads to the auto-transformer T-9 are not long enough to permit changing the connections as required for various line voltages. If the wires are stretched they may be connected but they cannot be clamped with the clamp provided.

(d) Bolts which hold capacitors C60 and C14 are not rigidly secured to the frame, adding to the difficulty of installing these units. It is suggested that the bolts be welded or otherwise firmly fastened to the cabinet to facilitate installations.

(e) Plate pin connectors for the type 829 exciter tubes, V12 and V13, force the tubes to one side when they are attached or detached. This results from the fact that the terminals to which the connector leads are secured, are located directly above and in line with the tube plate pins.

(f) Connection to the oscillator grid post can be made only with considerable difficulty, since the connection stud is located too close to the tube grid cap. To accommodate possible production variations in the length of the tube grid lead, it is recommended that the insulated strip, to which the stud is secured, be capable of adjustment to any desired position. Means for clamping the strip in the correct position should be provided.

(g) The grip connector for the oscillator grid coil short-circuits a turn of the coil unless it is very carefully adjusted.

(h) An offset screwdriver is required for the installation of the grid tuning coil. This tool has not been supplied with the equipment.

51. Effects of Temperature and Humidity.

(a) L4 and L5 should be replaced by a coil with ceramic forms to minimize the possibility of arc-overs during high humidity.

(b) Steps should be taken to prevent rust and corrosion caused by high humidity conditions.

(c) All condensers and other components which contain compounds should be so mounted that the compound does not leak from the container.

(d) The points where the test condenser clamps to the frame should be plated to prevent corrosion.

(e) Corrective measures are required to prevent relay failure

and sluggishness during conditions of low temperature such as described in par 38 above. This might be accomplished by the use of a suitable type of heater. However, it is deemed more desirable to incorporate a synchronous motor type of time delay in the design. To determine the suitability of a relay of this sort for incorporation in the Loran Transmitter, tests were run at the Laboratory on a Type No. TD1 relay manufactured by the R. W. Cramer Co., Inc., Centerbrook, Connecticut. It was found that this relay operated within one percent of a set value in the temperature range of 50°C to -15°C. The relay became increasingly sluggish in its operation at temperatures in the range of -15°C to -30°C. After being inoperative for two hours at a temperature of -30°C the time delay operated but was in 100% time error. However, operation was normal when the delay relay was allowed to remain in the operative stalled condition at -30°C. No overheating was observed after 8 hours of stalled operative service at 50°C. It is believed that the operation of this type of relay at low temperatures could be improved if the manufacturer were to employ some of the newer types of lubricants developed for use in aircraft where extreme variations in ambient temperature are encountered. The TD1 relay is panel mounted with all wiring and terminals behind the panel. An accurately calibrated dial plate shows the time delay to which the relay is adjusted. Its setting is continuously variable between 7 and 120 seconds so that a single type could be substituted for relays RE2TD, RE4TD, RE6TD, and RE9TD thereby facilitating the spare parts supply problem. The use of this type of time delay would also eliminate the use of oil filled relays in the equipment.

(f) The use of standard metallized or wire-wound types of multiplier resistors for the high voltage voltmeter is suggested. Carbon type multipliers are usually inaccurate, suffer from ageing effects, temperature variations, and humidity thereby resulting in serious errors in voltmeter readings.

(g) Better ventilation of tubes in the exciter and modulator units should be provided in new equipment models.

(h) Corona encountered during humidity should be eliminated by corrective action.

(i) The elimination of bakelite terminal boards is suggested where feasible, especially those carrying potentials in excess of 500 volts. The use of ceramic types of jacks and plugs is suggested.

(j) The canvas used as a flexible connection between the blower and the air duct should be thoroughly impregnated as a protection against destruction by fungus.

(k) The use of wood in the antenna matching house should be abandoned since prolonged exposure to the elements will result in deterioration.

(l) Ceramic coil forms should be substituted for the cloth-inserted bakelite forms employed in the antenna coupling unit.

52. Miscellaneous Defects.

(a) The friction drive knob on the oscillator plate tuning control was found to slip occasionally. A positive type of drive should be substituted.

(b) The front panel chart is held in position by a frame screwed to the panel. The frame must be removed to replace the chart. The use of a conventional type frame with an open top to permit easy removal or insertion of the chart is suggested.

(c) An inflammable transparent celluloid window is employed to cover the front panel chart. A plastic of no greater inflammability than cellulose acetate should be used.

(d) Dial locks to prevent accidental movement of the tuning controls have not been provided.

(e) Both units are equipped with doors in their top panel which must be opened while the equipment is operating. It is recommended that the doors be replaced with perforated shields to preclude the danger of small objects falling into the units while they are operating and to guard against accidental operation with the doors closed.

(f) Spot welding of the molding around the power-unit fan opening was unsatisfactory and the molding became loose. One handle welded to the side of the unit became loose.

(g) The oscillator blower sail-switch interlock rattles continuously unless carefully adjusted.

(h) Relay RE5 chatters loudly from time to time. Care should be exercised to insure proper adjustment of the relay at the factory before shipment.

(i) A majority of the resistors employed are not of an approved Navy type. These resistors, because of their dimensional differences, cannot be replaced with standard Navy resistors. Standard Navy resistors and clips should be adopted.

(j) The use of micro-switches for door interlocks is not considered satisfactory. The small plunger clearances and light spring tension of this type of switch makes it particularly subject to sticking if any corrosion should occur.

(k) The number 1 pins of all octal sockets are left floating. They should be placed at ground potential so as to ground the shells of all metal tubes which might be used in the equipment.

(l) Terminals on terminal board S1 in the radio frequency unit are so situated as to constitute an undue hazard to personnel. Plate 15 shows these terminals on the lower right side. This bakelite plug and jack should be eliminated and an enclosed ceramic type of plug and jack board substituted.

(m) The method of antenna transfer from dummy to real antenna is cumbersome. An arrangement should be provided for a manually operated front panel switch with a position indicator to facilitate a rapid changeover.

(n) The provisions and instructions for checking and servicing the exciter are poor. No point has been provided on the exciter for clamping the test condenser to the frame. The flexible lead on the test condenser is not insulated and not sufficiently long to reach the rather inaccessible points requiring checking of pulse shapes in the exciter. Models in current production should be provided with the necessary sizes of test condensers required. The points of attachment of the condenser for servicing should be clearly marked with arrows, color coding or some other method of rapid identification. It is suggested that in future models consideration be given to the provision of test jacks and plugs on the rear of the exciter employing low capacity wiring. The design should be such as to minimize the danger of operating personnel contacting high potentials; a constant hazard with the open test condenser and the open rear door.

(o) Compressible washers have not been provided to absorb stress set up in ceramic parts due to taking up mounting bolts and as a precautionary measure against misalignment caused by manufacturing tolerances. Attention is directed to par. 2-20 of Ref (d).

(p) Instructions should be provided near all relays indicating the amount and type of oil required for successful operation.

(q) Coil L6 in the sampling box, BC6, should be mounted on small stand-off insulators to preclude the possibility of the last turn of the coil making contact with the metal bushing.

(r) A permanent warning label should be affixed in plain view near the rear of the oscillator warning the operator against tampering with the overload discharge gaps.

(s) A suitable, portable discharge rod should be provided on the front of the radio frequency unit. This discharge device is required by the operator to discharge capacitors in the various circuits before attempting to make adjustments from the front.

(t) Resistor R87 in the Oscillator Bias and Modulator Screen Power Supply has been mounted on a bakelite support of inadequate mechanical strength. This resistor, shown in Plate 17, carries potentials approaching 500 volts. A support with liberal insula-

tion is desirable.

(u) Labeling fuses with the same number for exciter number 1 and exciter number 2 is confusing. The same numbers might be used, but a suffix should be used to designate the particular exciter in which the fuse is located.

(v) A rigid frame type of construction is not employed. Such a frame is desirable to withstand the rigors of the Naval service. Lifting eyes have not been provided to facilitate handling this heavy and bulky piece of equipment. Furthermore, it is deemed possible and desirable to reduce the dimensions of the equipment to a maximum of 22 inches in depth and 28 inches in width at the base.

(w) Since the equipment requires considerable servicing and adjusting with access doors open and high voltage applied, it is suggested that a suitable provision be made to short circuit the interlock while such servicing is being performed.

(x) It is believed that the locks used on doors may be eliminated. These locks hamper rapid access to the equipment if the keys are kept in a position other than in the lock. If the key is kept in the lock there is no value in employing the lock. There is also a possibility of losing keys despite the fact that a key is provided for each lock together with one spare for the entire equipment. Keys are interchangeable in the various locks. A standard type of door catch should be suitable.

(y) Resistor R5 in the radio frequency unit is operating at current values exceeding those recommended by the manufacturer. The resistor is used to control the potential being applied to the primary of the oscillator filament transformer. The variable resistor is rated by the Hardwick-Hindle Company at 7.75 maximum amperes. During normal operation this resistor carries 9.2 amperes.

(z) Modifications of the dial and drive mechanisms are desirable so as to comply with paragraphs 2-30, sub-paragraphs (1), (2), and (4) of ref (d) relating to clockwise rotation for increasing frequency, taper pin locking, dial stops, etc , all of which have been discussed in paragraph 23 of this report. Paragraph 3-29 of ref (d) requires each control to be identified by markings to indicate the function of the control and also to be designated by a letter from "A" to "Z".

(aa) It is suggested that consideration be given to the five control circuit modifications discussed in paragraph 21 above:

(1) Replacement of thermal line overload by fuse protection or a satisfactory type of compact line-switch magnetic type overload.

(2) Replacement of overload relay RE11 with a type providing adjustment within the range of currents encountered in the circuit.

(3) The incorporation of interlocking to prevent the application of plate potential to the oscillator when the modulator is not being keyed.

(4) Associating the lighting of PL-2 with the operation of relay RE10 as an indication to the operator that full power is being applied to the rectifier so that the rectifier H.V. Variac may be advanced.

(5) Replacement of the overloaded mercury switch in the sail switch ASW1.

(ab) The transmitter instruction book is lacking in certain details. Recommendations are made in paragraph 45 above.

(ac) The wire used in the exciter units is of the inflammable cotton-covered variety. This type of wire is also particularly susceptible to destruction by fungus in humid, tropical areas. Suitable wiring should be substituted.

(ad) The antenna coupling unit in the antenna coupling house has not been provided with any easy means of transmission line attachment. Standard fittings, similar to those employed in the antenna sampling loop, are suggested.

(ae) Difficulties with corona on transformers should be eliminated.

53. SUMMARY OF DEFECTS OF THE MODEL A1 SYLVANIA PRODUCTS COMPANY TESTING OSCILLOSCOPE.

The following defects noted during the investigation of the Testing Oscilloscope should receive consideration.

(a) Packing was inadequate to protect the oscilloscope. A number of loose screws were found when the unit was received.

(b) Three screws holding the front panel to the cabinet were missing.

(c) The VR-150 tube, symbol V-7, is set so close to condenser C-2 that the tube presses against the condenser and is not erect in its socket.

(d) Screws were not provided to attach the shield for the 5CP1 cathode-ray tube.

(e) In shipment, Choke L1 had loosened, swung on its leads and damaged the tube socket for tube V-5.

(f) Considerable backlash found in controls R-3 and R-6 was due to the use of cloth-inserted bakelite shafts attached to universal couplings of similar material. It is recommended that metal shafts be employed and that Isolantite couplings be installed.

(g) The plate lead (high voltage) from C1 to V2 is spaghetti covered and is pushed tightly against the metal control shaft of R53 resulting in a condition which will eventually wear off the spaghetti and result in a short circuit.

(h) The laced cable, parallel to and under the metal shaft of R53, is inadequately anchored so that it may rub against the shaft and shaft couplings.

(i) The wiring throughout the unit is not of the quality and workmanship usually found in Naval equipments. In numerous instances the wiring is inadequately laced and anchored, i.e.,

(1) Leads from transformer T-2.

(2) All wiring near V11, V12, and V13.

(3) Leads to and near R53, R51, and R54.

(4) Leads near R3 and R6.

(5) Filament leads to V1 and V2. Plate 34 shows a view of the oscilloscope wiring.

(j) The lead from T1 has no bushing at the 1800-volt terminal

(k) Fixed resistors do not have symbol identifying markings.

(l) A 110-volt line switch has not been provided.

(m) All controls used in normal operation, such as input switching, are not available for front panel operation.

(n) The intensifier lead to the type 5CP1 cathode-ray tube has not been equipped with an insulated shield.

(o) Interaction between vertical positioning, focus, intensity, and sweep speeds is excessive and undesirable.

(p) Potential differences greater than 500 volts are found across the bakelite strip supporting the bleeder resistors. The potential is also in excess of 500 volts across the bakelite supports to ground. Ceramic insulation is recommended for these applications.

(q) Indicators have not been provided to show "power-on"

conditions.

(r) The 5W4 low voltage rectifier is not on the Navy preferred list of approved tubes. (Paragraph 2-17 of ref (d)).

(s) Screen grid voltage applied to the type 6SJ7 tubes in positions V6, V9, and V13 are in excess of the maximum permitted by specification JAN-1A (See par. 14).

(t) The number 1 or ground pins on all metal tubes have not been connected to ground. These pins have been left "floating".

(u) Corrosion appeared on the chassis after four days of subjection to temperature and humidity tests.

(v) After being inoperative for a period of two hours at a temperature of 40°C, 95% relative humidity, the oscilloscope was observed to be operating at quite a higher beam intensity than when the equipment was turned off before beginning this test. This condition rectified itself after about 15 minutes of operation.

(w) The crystal oscillator method ("Confad") of frequency measurement is unsatisfactory and confusing. It should be removed.

(x) Since the sweep lengths are extremely variable and dependent on various operating conditions, it is suggested that provision be made to supply markers from the timer for purposes of sweep length calibration.

54. CONCLUSIONS.

Construction. The general construction and appearance of the Loran 575-BC equipment does not reflect the rugged, substantial design required to withstand the rigors of the Naval service, even if intended for shore installations only. The enclosing frame is dependent on welded 12-gauge metal for its mechanical strength. Since this equipment may be required to withstand difficult shipping and handling conditions, a higher degree of mechanical strength is desirable. The equipment in its present form could not be considered suitable for installation where it may be subjected to shock, vibration, or mounting on uneven or shifting surfaces. Considering the equipment as a whole, accessibility to parts is good, although an improvement could be effected by the use of ceramic plugs and jacks to facilitate the removal and servicing of the modulator and modulator screen-oscillator grid supply units. Tubes are easily replaced without removing units. No mechanical improvement can be suggested which does not involve a major redesign of the equipment. The wiring in the transmitter exciter and the monitoring oscilloscope are not up to the standards required in similar types of Naval equipment.

55. Circuit Stability. Line voltage variations had the greatest effect on circuit and frequency stability. A major portion of this difficulty could be alleviated by the use of constant-potential transformers to supply the oscillator filament transformers or by the employment of oscillator fialment transformers of the constant-potential type. Regulation of the oscillator filament transformer also resulted in better overall stability of the oscillator in that higher plate potentials could be applied without arc-overs. With suitable oscillator filament potential regulation, power output may be improved by an increase of at least 3 kv plate potential with the same stability in operation as experienced at the lower plate potential without filament regulation. If oscillator filament potentials are kept constant, the frequency stability is deemed satisfactory provided the band width of the Loran receivers is not further restricted. Improved frequency stability will result in minimizing interference to services operating on adjacent channels. The application of filters for harmonic suppression is desirable if the resultant pulse distortion does not appreciably affect the accuracy of the Loran system. A major improvement in circuit stability could be effected by isolating the grid flipper from ground to eliminate a frequent cause of arc-overs. The circuit stability of the equipment is particularly sensitive to accumulations of dust and dirt resulting in arc-overs and corona. Arc-overs across the glass between grid and plate elements of the oscillator tubes may be reduced by frequent cleaning or the incorporation of an improved air filter, such as the oil-filled type.

56. Effects of Temperature and Humidity. Variations in temperature and humidity should not cause serious difficulties if the equipment can be kept in operation so that the heat developed by the equipment will serve to stabilize conditions. High ambient temperatures also had little effect if the equipment was kept in operation, but if the equipment is exposed to low temperatures while inoperative failure and sluggishness will become apparent in the control system. Heat developed in the equipment will compensate for moderately moist atmospheres but failures are to be expected if an attempt is made to operate the equipment after it has remained idle in an atmosphere of high humidity. Fungus growths will attack certain wiring in the exciter and the flexible canvas couplings employed between the blower and the air duct to the oscillator tubes unless anti-fungus precautions are taken. Frequency stability during variations in temperature and humidity are not excessive provided the bandwidth of the Loran receivers is not further restricted. Future designs of the equipment must give consideration to the elimination of corona and arc-overs under humid conditions.

57. Safety and Protective Devices, Tubes and Components. Because of the high potentials employed, the equipment constitutes a hazard to operating personnel. The exposed type of servicing

required for the initial adjustment of the equipment, or in event of failure, constitutes a real hazard to personnel. When assigning personnel to Loran installations, it will prove desirable to assign operators with considerable high voltage experience. Certain changes have been suggested herein for the improvement and incorporation of safety and protective devices. Indication has also been given of desirable changes of tube types. New models of equipment should be improved by the selection of more desirable components.

TABLE 1

LORAN 575-BC TRANSMITTING EQUIPMENT

WEIGHTS AND DIMENSIONS

In Shipping Crates

Unit	Weight (lbs.)	Length (in.)	Width (in.)	Weight (in.)
Radio Frecuency Unit		45	39	76
Power Supply Unit		45	39	76
Transmitter Testing Oscilloscope	(Shipping Crate sizes vary)			
Antenna Coupling House Unit	(Shipped Uncrated)			

Uncrated and in Operating Position

Radio Frequency Unit	722-1/4	32-1/2	28	72
Power Supply Unit	1074	32-1/2	28	72
Transmitter Testing Oscilloscope	83	18-1.4	13-3/4	18-1/8
Antenna Coupling House Unit	----	32-1/4	30-1/4	48-1/4

Note: When the equipment is placed in operating position, 27-1/2 inches must be allowed at the front and rear of the equipment so that the doors may be opened to gain access to the equipment. Ten and one quarter inches of space is required on top to permit opening the ventilation doors. An additional 18-1/4 inches must be allowed on the right side of the transmitter for the hanging of an 18 inch by 27 inch shelf on which the monitoring oscilloscope is placed. The top of the shelf is 37-1/2 inches above the deck. The oscilloscope has a slanting panel as may be seen in Plate 30.

TABLE 2

LORAN 575-BC TRANSMITTING EQUIPMENT

TUBE POTENTIALS

Tube No.	Tube Type	Application	E_f (Volts)	E_p (Volts)	I_p (ma)	E_g (Volts)	E_{g2} (Volts)
		Radio Frequency Unit					
V1, V2	VR98A	Oscillator	8.3	15130	20.1	-1970	(I_f 34 amps
V14	715A	Modulator	26.0	2370	4.25	-400	485
V17	2X2	Rectifier	2.35	560	5.1	----	---
		Power Supply Unit					
V5	5W4	Rectifier	5.2	(Plate to Plate - 655 volts).			
V6	2X2	Rectifier	2.5	1320	0.6	----	---
V7	2X2	Rectifier	2.5	1320	8.1	----	---
V8	6J5	Preamplifier	6.25	127	---	-5.3	---
V9	6SK7	Amplifier	6.25	68	---	-2.4	96
V10	6ZY5	Diode	6.18	(Cathode is -600 volts off ground potential)			
V11	2050	Pulse Former	6.3	340	---	40	---
V12, V13	829	Drivers	6.3	1545*	0.95	-150	434
V14, V15	5V4G	Diode	6.3	----	---	----	---
		Sylvania Model A1 Transmitter Testing Oscilloscope					
V1	2X2	Rectifier	2.7	----	---	----	---
V2	2X2	Rectifier	2.7	----	---	----	---
V3	6H6	Intensifier	6.55	----	---	----	---
V4	5CP1	Cathode-Ray	6.55	E_g - 0V minimum and -210 volts maximum; Anode 1 - 800 V max.; Anode 2 - 1700 V. max.; Anode 3 - 4000 V.			
V5	5W4	Rectifier	5.0	(Plate to Plate - 730 volts).			
V6	6SJ7	Oscillator	6.25	310	---	----	207*
V7	VR150	Regulator	(12.5 ma. current flowing).				
V8	VR75	Regulator	(28 ma. current flowing).				
V9	6SJ7	Amplifier	6.25	263	---	----	153*
V10	6H6	Diode	6.25				
V11	6SJ7	Sweep Gen.	6.25	295	---	----	60
			(Suppressor Potential is 75 volts)				
V12	6H6	Diode	6.25	---	---	----	---
V13	6SJ7	Amplifier	6.25	218	---	----	152*
V14	6H6	Diode	6.25	---	---	----	---

(Continued)

TABLE 2 (Cont'd)

Note 1: Transmitter Potentials were measured at 230 line volts.
Note 2: Oscilloscope Potentials were measured at 115 line volts.
Note 3: D.C. potentials were measured with RCA Voltohmysts.
Note 4: (*) Asterisk denotes a specification violation. Detailed discussion on violations is found in Par. 12.
Note 5: Specification requirements are contained in Par. 2-17 of ref (d).
Note 6: All potentials, excpet heater potentials are recorded as the potential existing between cathode and the designated element of the tube under consideration.

TABLE 3

LORAN 575-BC TRANSMITTING EQUIPMENT

INVESTIGATION OF FUSES AND OVERLOAD RELAYS

Part No.	Circuit	Mfgr's. Type Number	Rating (Amps.)	Measured Amperes
	Exciter Unit			
F-7	Pri. of T-6 of No. 1 Exciter	Buss 3AG	1.0	0.52
F-8	Pri. of T-7 of No. 1 Exciter	Buss 3AG	1.0	0.15
F-9	Pri. of T-5	Buss 3AG	1.0	0.39
F-10	Pri. of T-8	Buss 3AG	1.0	0.25
*F-7	Pri. of T-6 of No. 2 Exciter	Buss 3AG	1.0	0.52
*F-8	Pri. of T-7 of No. 2 Exciter	Buss 3AG	1.0	0.15
	Oscillator Bias Supply			
*F-1	Osc. Bias Transformer (Shown on F-5 in the instruction book)	Buss 3AG	1.0	0.15
	Oscillator Section			
F-6	Meter Lights	Buss 3AG	1.0	0.29
	Power Supply Section			
*F-6	Meter Lights	Buss 3AG	1.0	0.15
**F-5	Osc. Blower Motor	Jeff.#300	15.0	1.9
**F-4	Mod-Screen Supply	Jeff #300	15.0	0 15
**F-3	Osc. Filament	Jeff.#300	15.0	9.20
**F-2	Panel Outlet	Jeff.#300	15.0	----
**F-1	Rectifier Unit Blower	Jeff.#300	15.0	0.415

All fuses carry a rating of 250 volts. The measured voltage under operating conditions does not exceed 115 volts.

Note: * These symbols have been used twice thereby leading to confusion.
** Renewable type.

Fuses have not been provided in the main AC supply line although a thermally operated fifty ampere circuit breaker has been incorporated in the main line switch. A test showed that the thermal breaker tripped in 35 sec. with a 100-ampere load. Seventeen seconds were required to restore it to normal operation. The maximum current through this line switch at 250 line volts, single pulsed, was found to be 13.2 amperes.

(Continued)

TABLE 3 (Cont'd)

Setting of DC Overload Relay RE-11.

Current required to open the overload when adjusted as shipped -	56 ma.
Minimum current setting of the overload relay - - - - - -	43 ma.
Actual current through the relay- - - - - - - - - - - - - (Single pulsing, 17.5 KV Osc. Potential)	11.8 ma.

A check of the time delay relays revealed that they had been correctly adjusted at the factory.

TABLE 4

LORAN 575-BC TRANSMITTING EQUIPMENT

LIST OF SPARE PARTS FURNISHED

35 Fuses, 1 Amp. 250 volts, Type 3AG.

10 Fuses, 15 Amp. 250 volts, Renewable.

50 Fuses, 15 Amp. 250 volts, Spare Links.

5 Koolohm Resistors, 10NI, 50 ohms, 10 watts.

5 Koolohm Resistors, 5NI, 50 ohms, 5 watts.

One complete set of spare tubes for the transmitter and rectifier units. (For tube types consult tube complement list in Table 2 of this report.).
No spare tubes were supplies for the monitoring oscilloscope.

Specification requirements for spare parts may be found by referring to Section VII of reference (c).

TABLE 5

LORAN 575-BC TRANSMITTING EQUIPMENT

POWER REQUIRED FROM THE SUPPLY LINE

Line Volts	Line Amps.	Input KVA	Input KW	Power Factor (%)	Power Factor Condition
Single Pulsing (17.5 Kv. Oscillator High Voltage)					
207	10.10	2.090	1.729	82.7	Lagging
230	11.60	2.668	2.120	79.5	Lagging
253	13.20	3.341	2.545	76.1	Lagging
Single Pulsing (17.5 Kv. Oscillator High Voltage) (Oscillator E_f regulated by method described in Par. 34)					
207	10.85	2.248	2.178	96.8	Lagging
230	10.75	2.472	2.380	96.3	Lagging
253	10.69	2.705	2.608	96.2	Lagging
Double Pulsing (17.5 Kv. Oscillator High Voltage)					
207	11.25	2.329	1.936	83.2	Lagging
230	12.90	2.968	2.382	80.3	Lagging
253	14.32	3.622	2.900	79.8	Lagging
Double Pulsing (Oscillator E_f regulated by method described in Par. 34)					
207	11.65	2.410	2.359	97.9	Leading
230	11.70	2.692	2.600	96.5	Leading
253	11.89	3.008	2.900	96.3	Leading
Standby Condition (Everything "on" but Oscillator High Voltage)					
207	8.10	1.675	1.350	80.6	Lagging
230	9.00	2.070	1.596	77.1	Lagging
253	10.10	2.555	1.890	74.0	Lagging
Sylvania Model A1 Transmitter Testing Oscilloscope					
		VA	Watts		
103.5	0.62	64.18	55.0	85.0	Lagging
115.0	0.72	85.10	68.0	82.0	Lagging
126.5	0.85	109.50	82.0	74.6	Lagging

TABLE 6

LORAN 575-BC TRANSMITTING EQUIPMENT

EFFECTS OF VOLTAGE VARIATIONS
(See Par. 33 for discussion)

Line (Volts)	Line (Amps.)	Freq. (Kcs.)	Mod. Cath. (Ma.)	Osc. Grid (Ma.)	RF Line 1 (Amps.)	Osc. Cath. (Ma.)	Osc. H.V. (Kv)
207	10.10	1868	8.5	1.4	1.35	14.9	16.0
230	11.60	1850	10.1	1.7	1.53	19.9	17.5
253	13.20	1845	11.6	2.0	1.68	22.9	19.2
Variation of Line Voltage with the Oscillator Filament Potential Constant. (Note 2)							
207	10.85	Note 3	8.75	1.55	1.38	17.2	16.0
230	10.75	1850	10.10	1.70	1.53	19.9	17.5
253	10.69	Note 3	11.25	1.90	1.65	20.5	19.2

Variation of Oscillator Filament Transformer Primary Voltage Keeping Other Voltages Constant.

96.3 volts - 1872 kcs.
107.0 volts - 1850 kcs.
117.7 volts - 1846 kcs.

Variation of Oscillator Plate Voltage Keeping Other Voltages Constant.

7.5 kv. - 1853.2 kcs.
17.5 kv. - 1850.0 kcs.
19.25 kv. - 1849.5 kcs.

Note 1: The voltage variations were accomplished in approximately one minute. Single pulsing at rate number 6 was employed during the tests. The transmitter was operating into its dummy antenna.

Note 2: Each Oscillator Filament transformer was supplied with constant potential by a Thordarson Automatic Voltage Regulating Transformer (T-9V32). These transformers kept the potential applied to the primary of the filament transformers constant within 0.7 volts through the range of variation.

Note 3: Frequency variations were so small that they fell within the instrument error of the General Radio Type 224 Radio Frequency Wavemeter used for frequency measurements.

TABLE 7

LORAN 575-BC TRANSMITTING EQUIPMENT

HARMONIC FIELD STRENGTHS WITH ANTENNA CONNECTED

Distance from Transmitter Wave Lengths	3700 kc.	5550 kc.	7400 kc.	9250 kc.	11,100 kc.	12,950 kc.	14,800 kc.	16,650 kc.
1 (Note 3)	5400	1560	2280	3600	1320	1200	200	55
2 (Note 3)	850	1000	----	408	----	----	---	--
5 (Note 4)	420	840	----	396	----	----	---	--
10 (Note 4)	132	600	----	---	----	----	---	--

Note 1: Readings taken in microvolts per meter with OF-2 Field Strength Indicator.

Note 2: The OF-2 Radio Interference Locator is a Noise Instrument with a charge time of less than 1 microsecond and a discharge time of about 600 microseconds. A series of readings were obtained on this instrument simultaenously with the Model 43A Jansky & Baily Loran Field Strength Indicator at various frequencies in the range of the transmitter. An almost constant ratio of 1:12 was observed between the readings of the OF-2 and the 43A at several signal strength intensities. The strength of the harmonics of the 575-BC transmitter were then measured with the OF-2 and multiplied by 12 to give the readings recorded above.

Note 3: Measured over land.

Note 4: Measured over water.

TABLE 8

LORAN 575-BC TRANSMITTING EQUIPMENT

VARIATION IN AMBIENT TEMPERATURE

Note 1 Time	Temp. (°C)	Rel. Hum. (%)	Freq. (Kcs.)	AC Line Volts	Mod. Cath. (Ma.)	Osc. Grid (Ma)	RF Line 1 (Amps.)	Osc. Cath. (Ma.)
1125	50.0	29.0	1858.2	234.0	9.75	1.4	1.56	19.4
1145	35.0	29.0	1854.9	235.0	9.80	1.4	1.53	19.6
1200	34.5	32.0	1855.6	236.0	10.00	1.4	1.55	19.8
1215	35.0	31.0	1855.6	236.0	10.00	1.4	1.55	19.8
1230	35.0	31.0	1855.6	236.0	9.80	1.4	1.52	19.4
1245	35.0	30.0	1855.0	234.0	9.90	1.4	1.53	19.6
1300	20.0	31.0	1854.3	232.0	10.00	1.4	1.53	19.4
1315	19.7	30.0	1856.3	232.0	10.00	1.4	1.53	19.6
1330	20.0	27.0	1855.6	233.0	10.00	1.4	1.54	19.8
1345	20.0	27.0	1855.6	232.0	10.00	1.41	1.54	19.6
1400	20.0	27.0	1855.6	232.0	10.00	1.41	1.54	19.7
1410	10.0	32.0	1854.9	232.0	10.0	1.41	1.54	19.7
1425	10.0	32.0	1855.6	232.0	10.1	1.42	1.56	19.7
1440	10.0	31.0	1856.9	232.5	10.1	1.42	1.56	19.8
1455	10.0	32.0	1856.9	233.0	10.2	1.42	1.56	20.0
1510	10.0	32.0	1856.3	232.0	10.1	1.42	1.54	19.9
1520	0.0	----	1857.6	233.0	10.25	1.50	1.56	19.9
1535	0.0	----	1856.3	234.0	10.25	1.45	1.57	20.1
1550	0.0	----	1856.3	235.0	10.40	1.50	1.58	20.25
1605	0.0	----	1855.0	232.0	10.30	1.50	1.56	20.0
1620	0.0	----	1854.3	236.0	10.40	1.45	1.57	20.4

Summary

Temperature Change Degrees C.	Carrier Kilocycles Change	Per Cent Change per Degree C.
50 - 35	3.2	0.0115
35 - 20	0.6	0.0021
20 - 10	0.7	0.0037
10 - 0	2.0	0.0117
50 - 0	3.9	0.0041

(Continued)

TABLE 8 (Cont'd)

Note 1: The equipment was in operation for 1-1/2 hours at 50°C, 29% Rel. Humidity, previous to the recording of the data above. Data was not recorded during this period due to power interruptions and severe line voltage variations at the Laboratory.

Note 2: Frequency Measurements were made with a General Radio Type 224 Radio Frequency Wavemeter. The Transmitter was single pulsed at rate number 6.

Note 3: See Par. 36 for details on monitoring during the test.

TABLE 9

LORAN 575-BC TRANSMITTING EQUIPMENT

VARIATION IN HUMIDITY

Time	Temp. (°C)	Rel. Hum. (%)	Freq. (Kcs)	AC Line Volts	Mod. Cath. (Ma.)	Osc. Grid (Ma.)	RF Line 1 (Amps.)	Osc. Cath. (Ma.)
0900	40.0	30.0	1854.5	231.0	9.9	1.42	1.52	19.4
0915	40.0	30.0	1854.5	230.0	9.0	1.39	1.52	19.6
0928	(Transmitter off for 2 minutes due to supply line voltage failure).							
0945	39.8	30.0	1850.3	231.5	10.0	1.30	1.53	20.1
1000	40.0	30.0	1852.7	230.5	9.9	1.28	1.53	19.9
1015	40.0	30.0	1852.5	232.0	10.0	1.20	1.54	20.1
1030	40.0	93.0	1851.0	232.0	10.0	1.20	1.54	19.9
1045	40.0	95.0	1849.8	233.0	10.0	1.20	1.54	20.0
1100	40.0	95.0	1851.0	232.5	10.0	1.15	1.54	20.0
1115	40.0	95.0	1850.5	233.0	10.0	1.2	1.54	19.9
1130	40.0	95.0	1851.5	233.0	10.0	1.15	1.56	20.0
1145	40.0	30.0	1852.3	234.0	10.0	1.15	1.54	20.1
1200	40.0	30.0	1851.0	235.0	10.1	1.05	1.55	20.2
1215	40.0	30.0	1052.3	235.0	10.0	1.05	1.55	20.1
1230	40.0	30.0	1852.0	235.0	10.0	1.15	1.55	20.0
1245	40.0	30.0	1852.0	234.0	10.0	1.21	1.52	20.3
Temperature lowered during this period, transmitter in operation.								
1315	-11.0	----	1854.5	232.0	10.0	1.20	1.56	20.0
1330	-15.0	----	1855.4	233.0	10.2	1.20	1.56	20.5
1345	-15.0	----	1855.0	234.0	10.4	1.20	1.59	20.5
Transmitter turned off. Temperature held at -15°C.								
*1545	-15.0	----	1854.5	234.0	13.5	1.6	1.62	20.0
1600	-15.0	----	1854.5	234.0	13.0	1.6	1.58	19.6
1615	-15.0	----	1854.5	234.0	10.5	1.5	1.59	20.0

Carrier frequency at end of first test period: 1852.5 Kcs.

Carrier frequency of greatest subsequent change due to variation in humidity: 1849.8 Kcs.

Maximum frequency change due to humidity: 2.7 kc; 0.146%.

(Continued)

TABLE 9 (Cont'd)

Note 1: Relay 2TD sluggish.
Relay 5 caused interlock failure. Condenser shorting relay stuck in up position.
Relay 9TD was slow and sluggish.

Note 2: Frequency Measurements were made with a General Radio Type 224 Radio Frequency Wavemeter.

Note 3: See Par. 36 for details on monitoring during the test.

TABLE 10

LORAN 575-BC TRANSMITTING EQUIPMENT

SUBJECTION TO HIGH HUMIDITY

Time	Temp. (°C)	Rel. Hum. (%)	Freq. (Kcs.)	AC Line Volts	Mod. Cath. (Ma.)	Osc Grid (Ma.)	RF Line 1 (Amps.)	Osc. HV (Kv.)	Osc. Cath. (Ma.)
(4 Nov.)									
0930	28	30	Transmitter started and set for normal operation.						
0930	28	30	1857.5	234.0	10.25	1.65	1.56	17.5	19.55
0945	Transmitter turned off.								
1015	40	95							
1215	40	95	Attempted to turn on the equipment. See paragraph 39 of this report for a discussion of failures and modifications.						
1330	40	95	After modification transmitter started normally. 12 Kv. was the maximum plate potential permissible because of corona on H.V. and Filament transformers; Frecuent arcing occurred from Grid to Plate of Oscillator tubes. High Voltage Voltmeter read incorrectly due to moisture on the multiplier. See paragraph 39 of this report for detailed discussion.						
1400	40	95	1861.4	Transmitter began to operate normally at 17.5 Kv. Plate potential when arc-overs became less frecuent than one arc-over every few minutes.					
1500	40	95	1859.0	238.0	10.0	1.41	1.52		20.4
(Restored to normal operating conditions)									
1630	40	95	1859.1	238.0	10.0	1.41	1.52		20.4
Moderate Humidity Overnight (Transmitter off -- stopped at 1630)									
(5 Nov) - Transmitter and monitoring oscilloscope started and operated normally at 0815.									
0815	20	50	1857.4	235.0	10.1	1.40	1.50		20.2
0845	20	50	1860.3	233.0	9.9	1.50	1.47		19.5

(Continued)

TABLE 10 (Cont'd)

Note 1: Frequency measurements were made with a General Radio Type 224 Radio Frequency Wavemeter. The transmitter was single pulsed at Rate number 6.

Note 2: See paragraph 36 of this report for details on monitoring during the test.

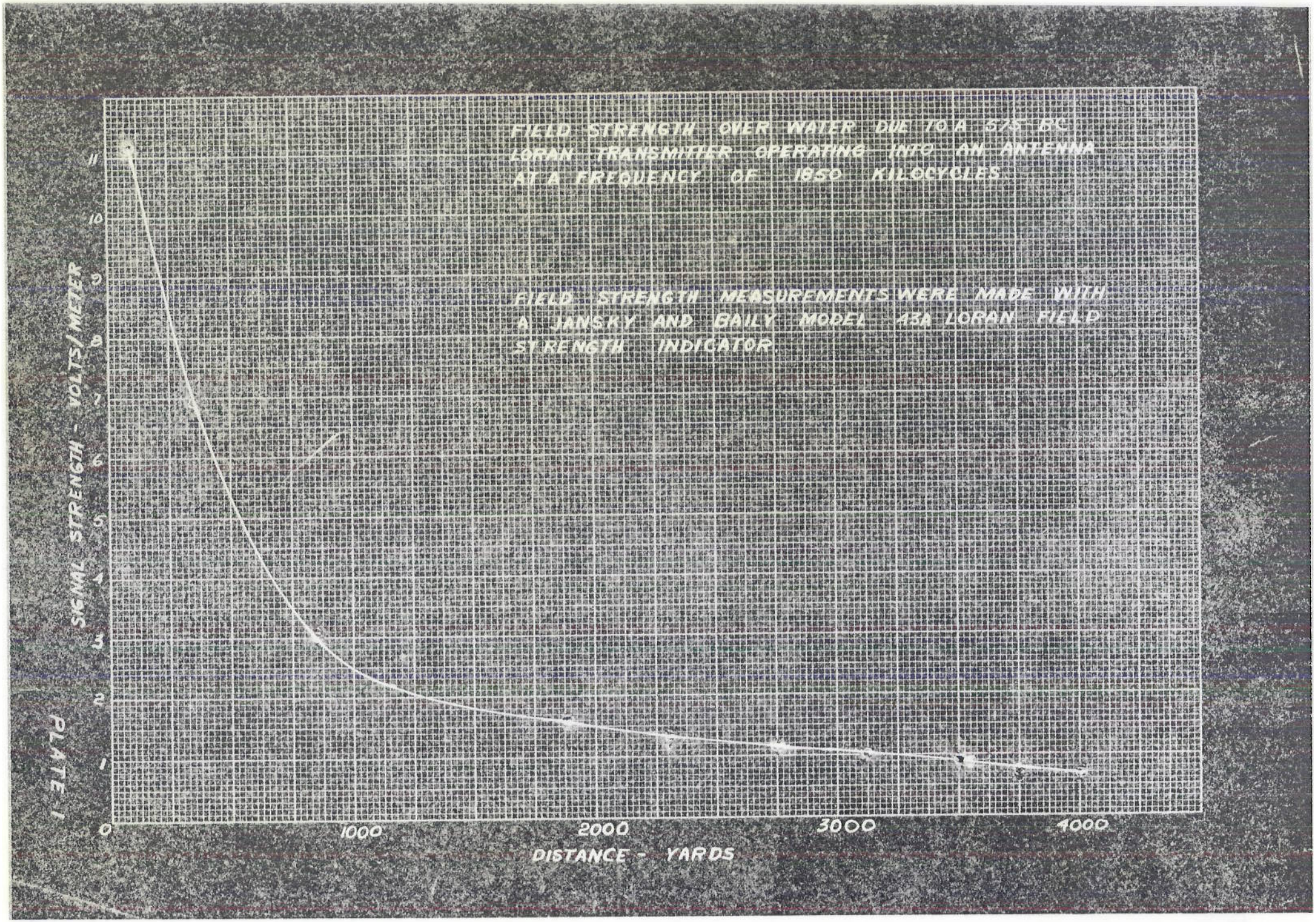

FIELD STRENGTH OVER WATER DUE TO A 375 K.C. LORAN TRANSMITTER OPERATING INTO ONE ANTENNA AT A FREQUENCY OF 1850 KILOCYCLES.
FIELD STRENGTH MEASUREMENTS WERE MADE WITH A JANSKY AND BAILY MODEL 43A LORAN FIELD STRENGTH INDICATOR.
SIGNAL STRENGTH - VOLTS/METER
0
1
2
3
4
5
6
7
8
9
10
11
1000
2000
3000
4000
DISTANCE - YARDS

PLATE I

FIELD STRENGTH OVER WATER DUE TO A 625-BC LORAN TRANSMITTER OPERATING INTO ITS DUMMY ANTENNA AT A FREQUENCY OF 1850 KILOCYCLES.

FIELD STRENGTH MEASUREMENTS WERE MADE WITH A JANSKY AND BAILY MODEL 43A LORAN FIELD STRENGTH INDICATOR.

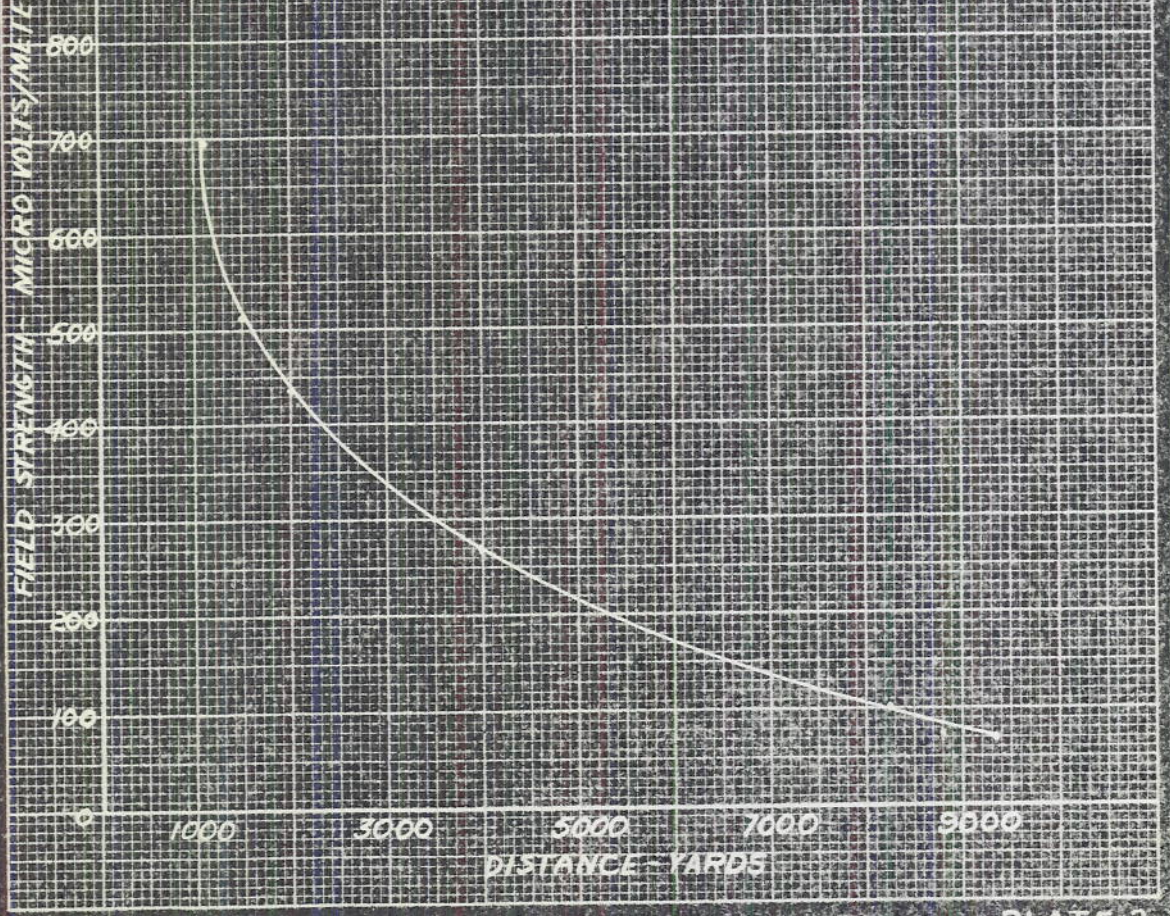


PLATE 2

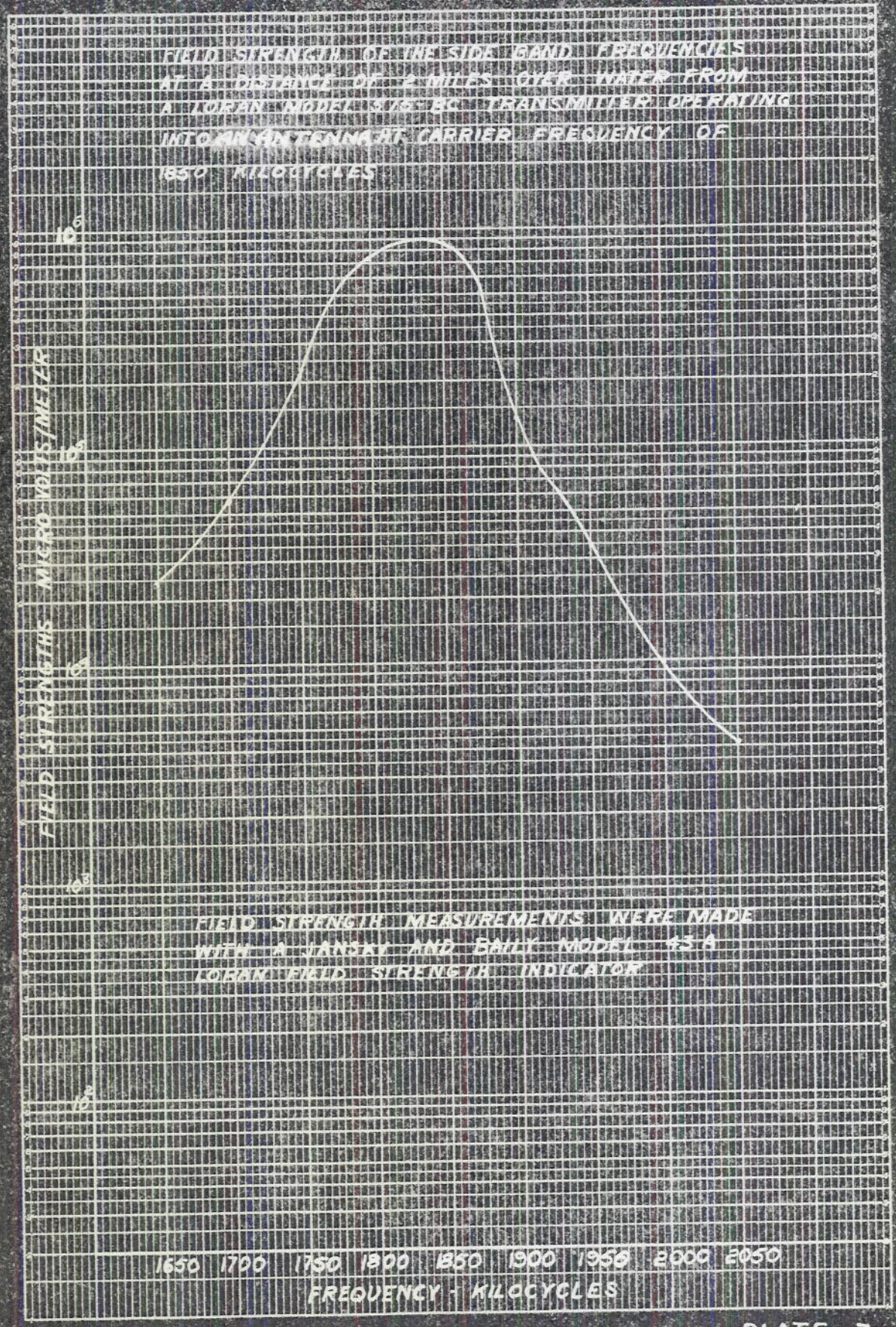

FIELD STRENGTH IN MICRO VOLTS/METER
10^6
10^5
10^4
10^3
1650 1700 1750 1800 1850 1900 1950 2000 2050
FREQUENCY - KILOCYCLES

PLATE 3



PLATE 4

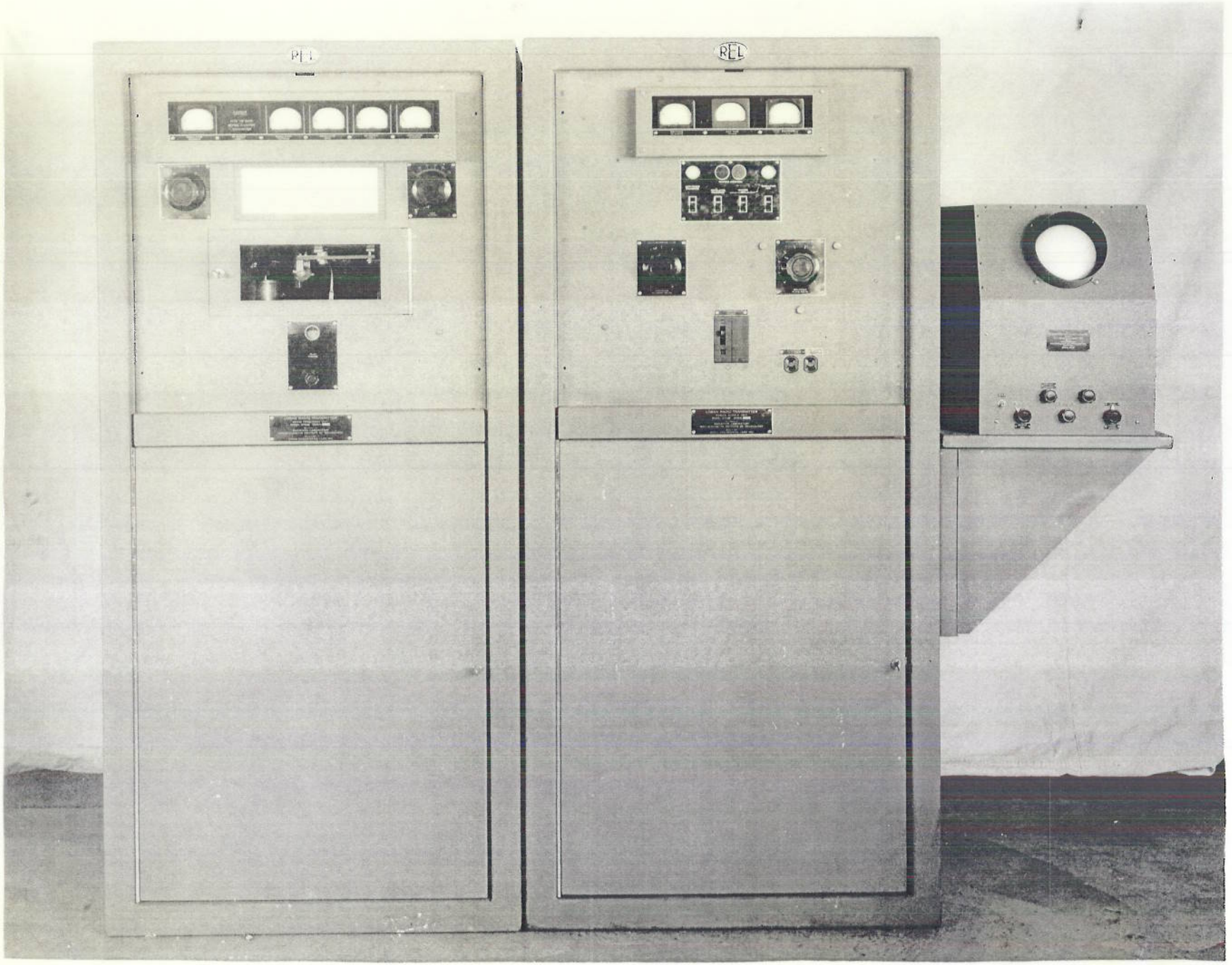


PLATE 5

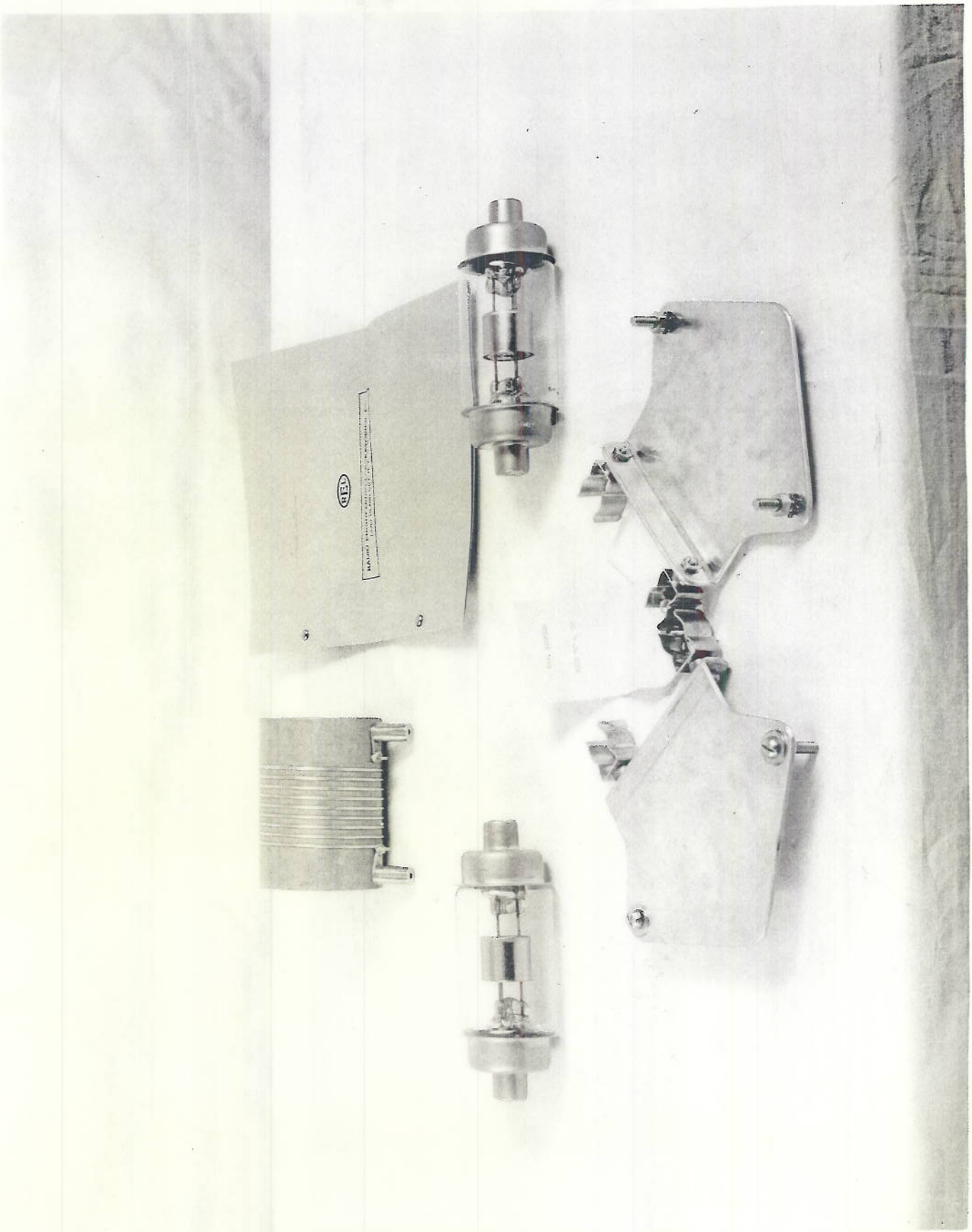


PLATE 6

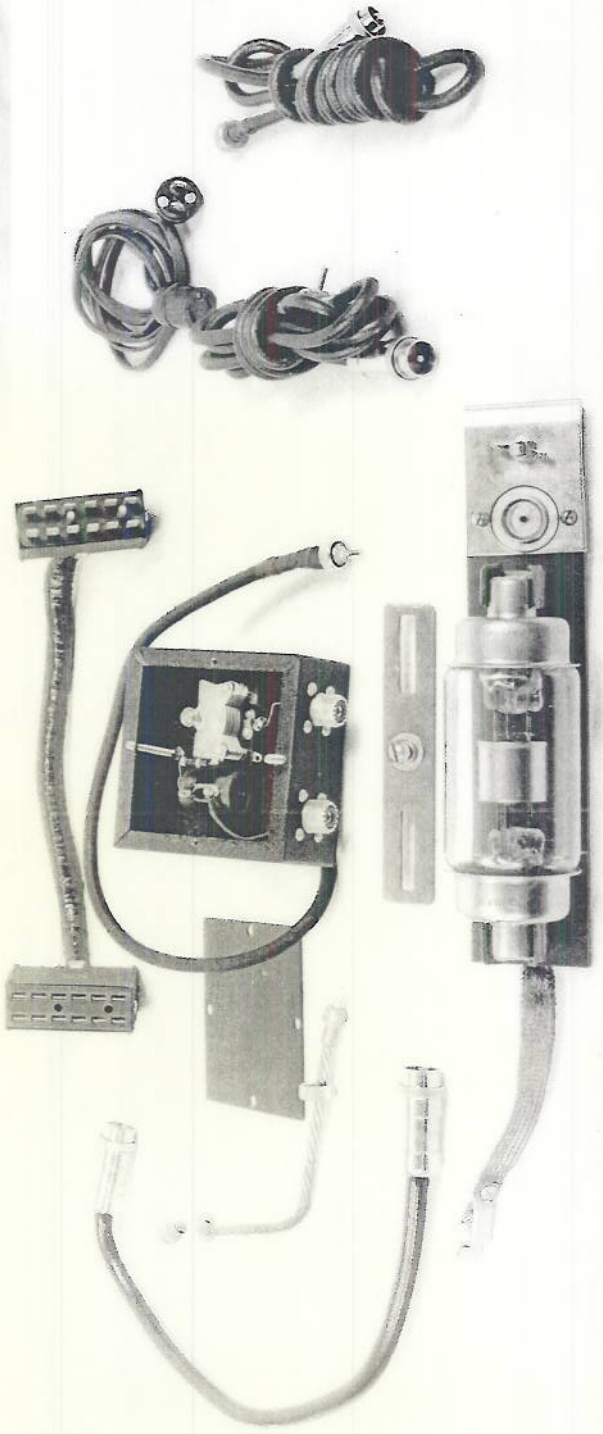


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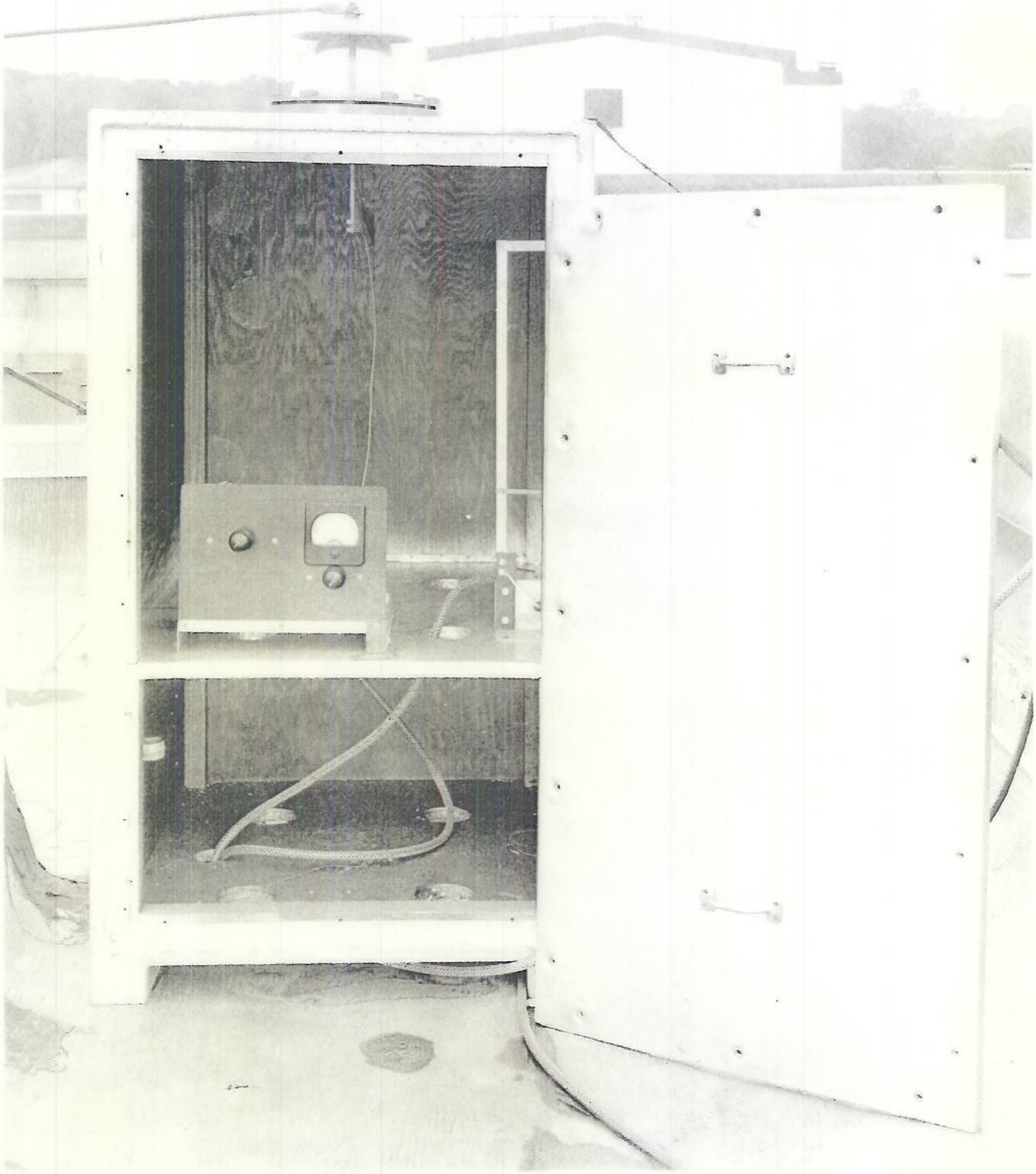


PLATE 8

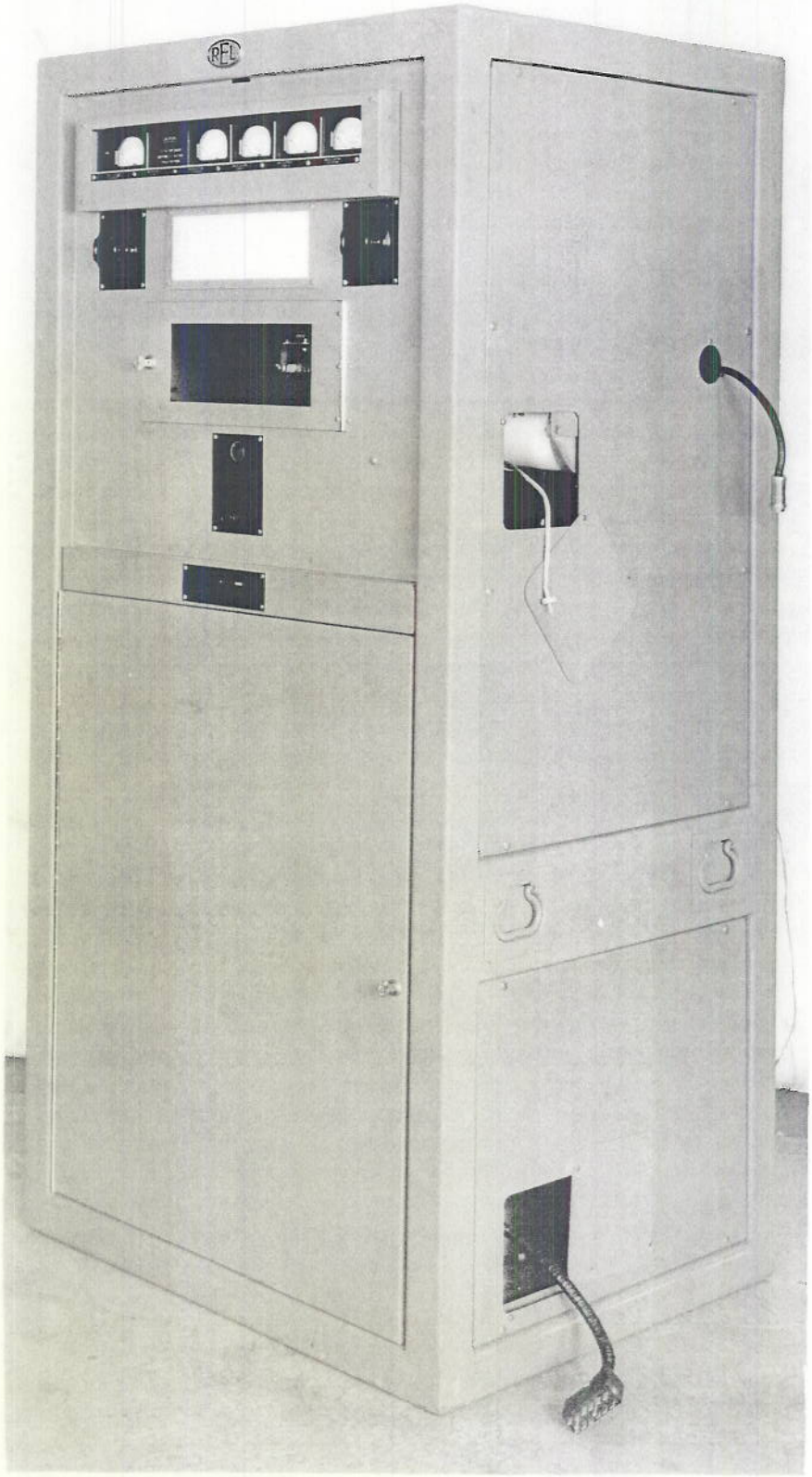


PLATE 9

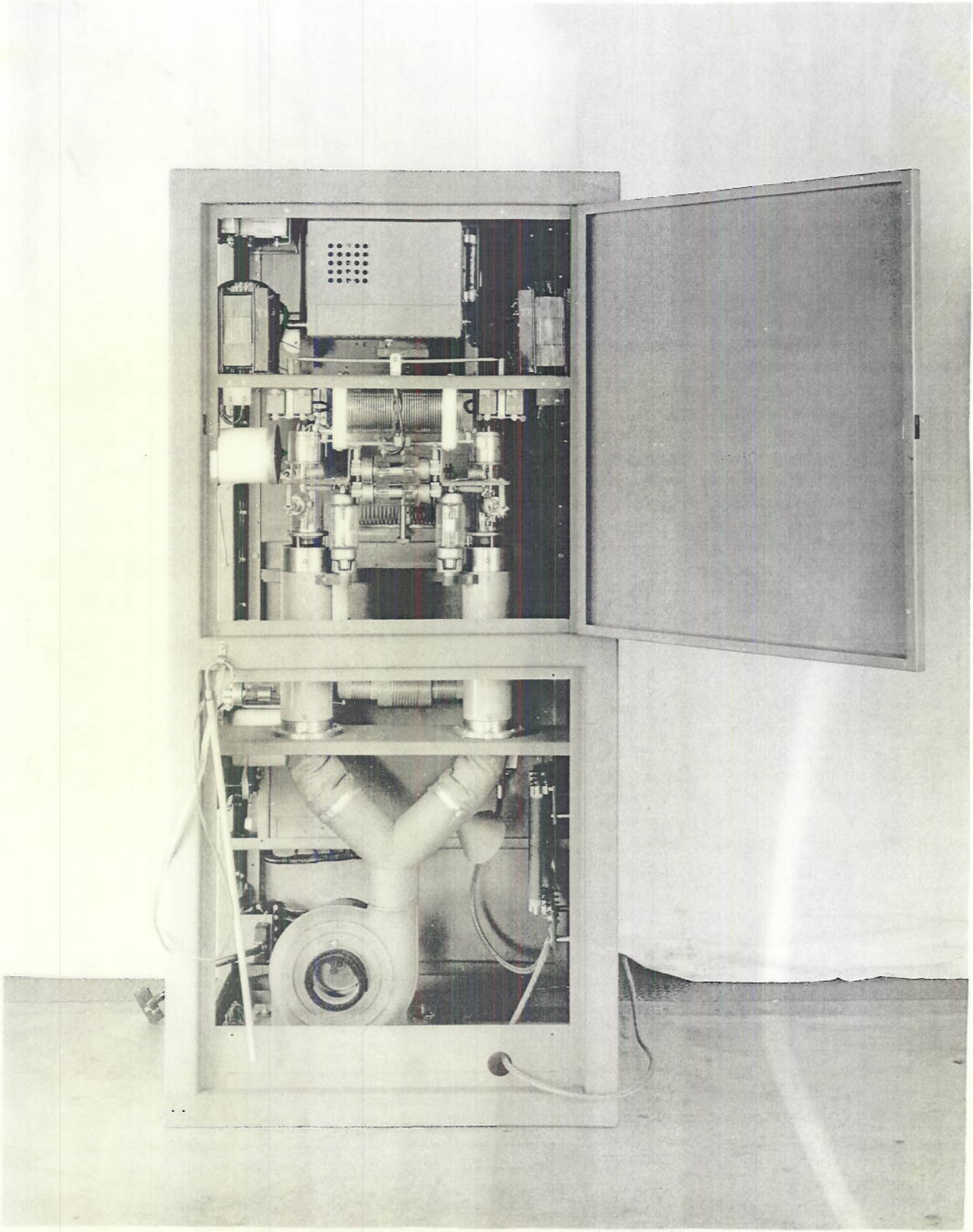


PLATE 10

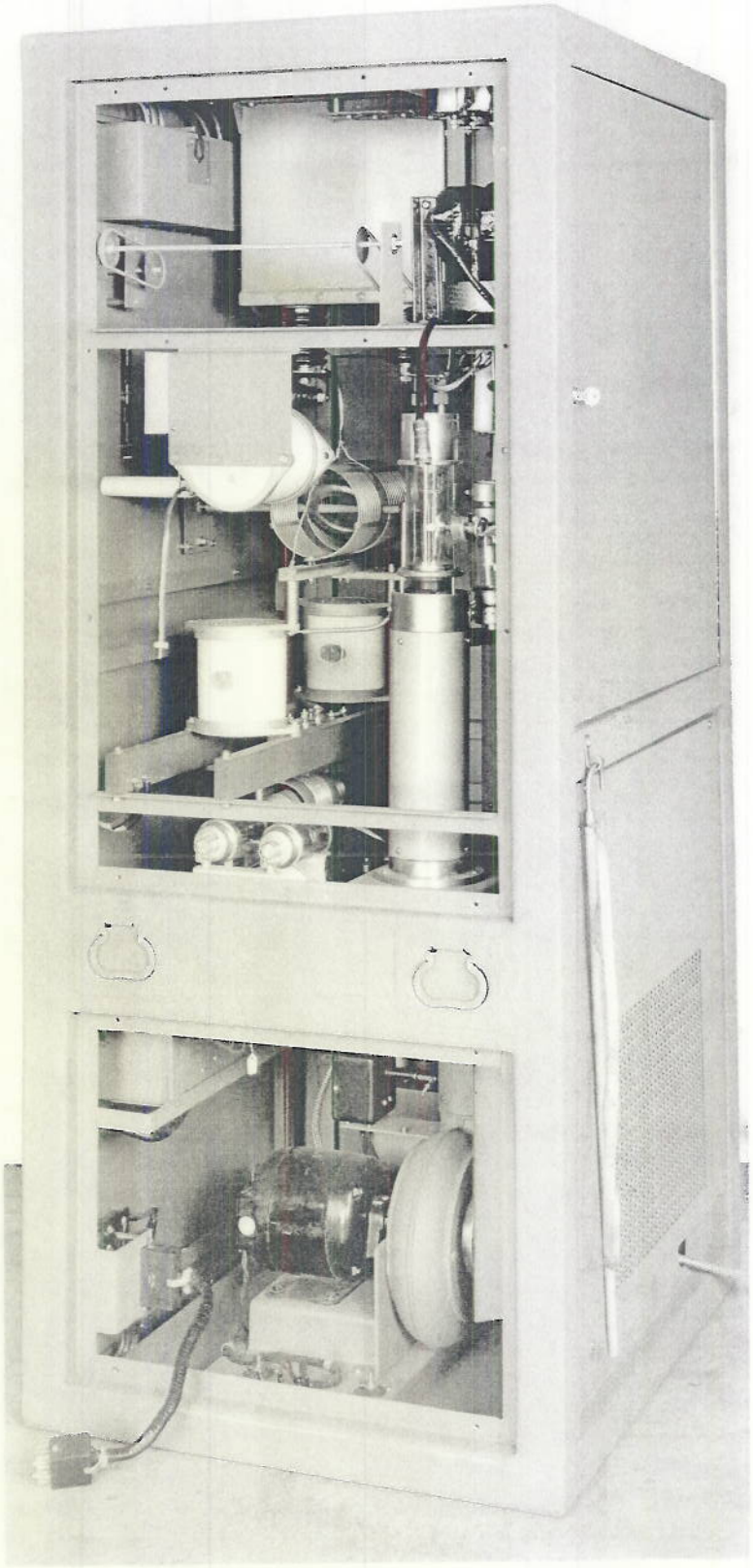


PLATE II

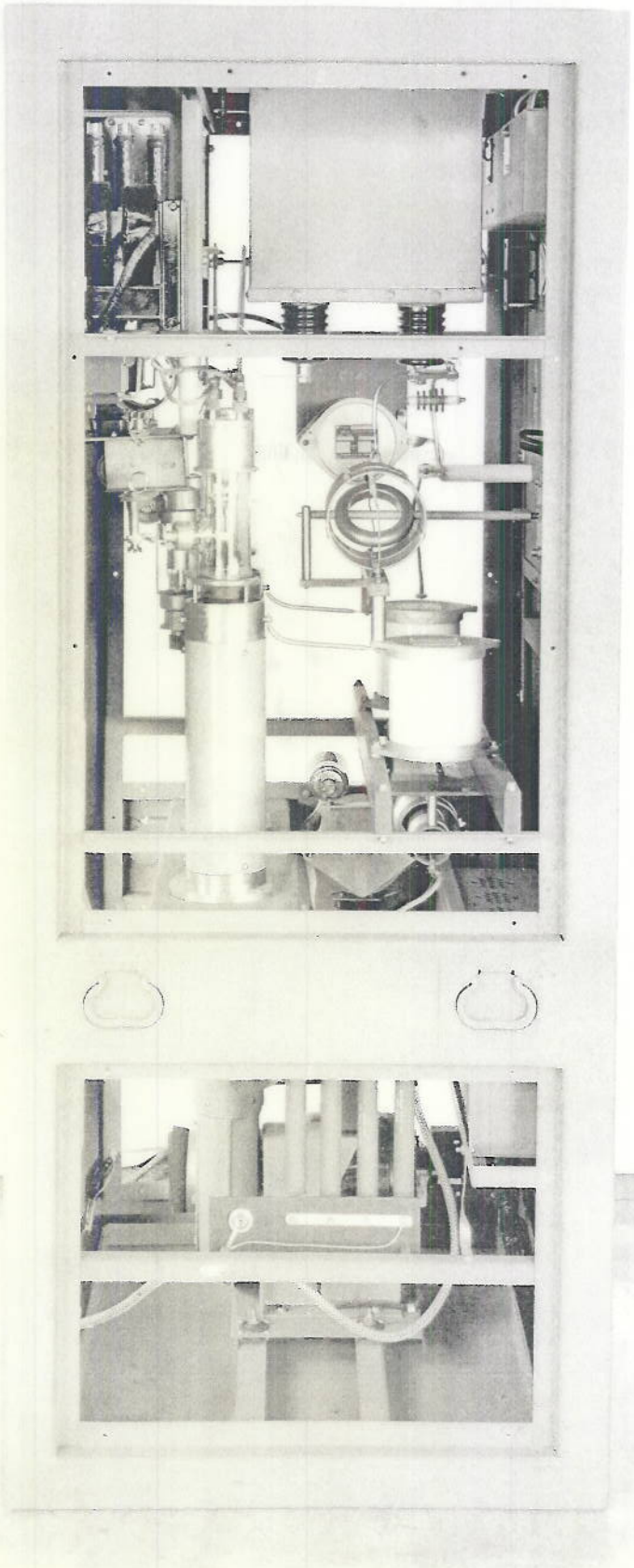


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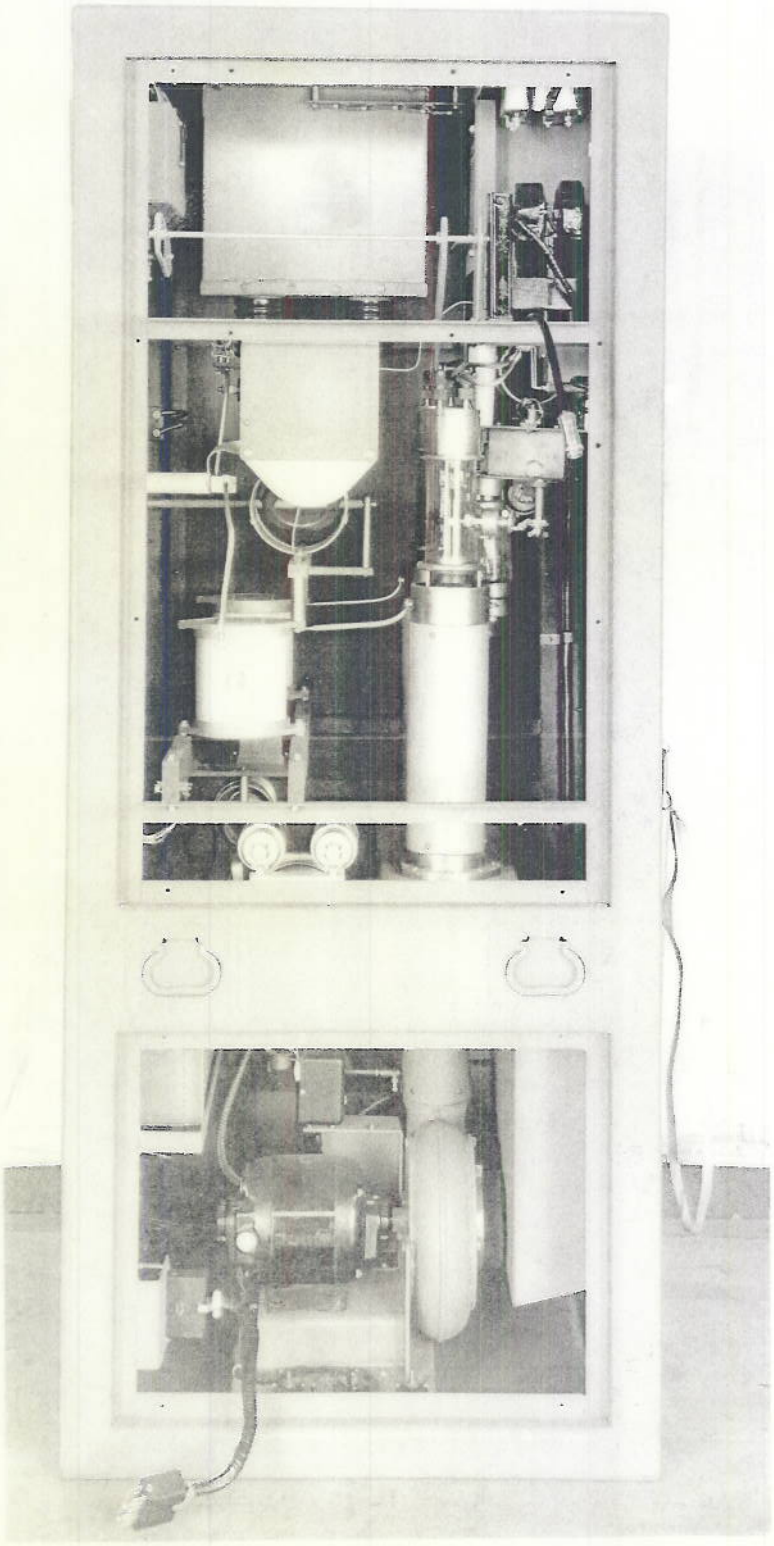


PLATE 13

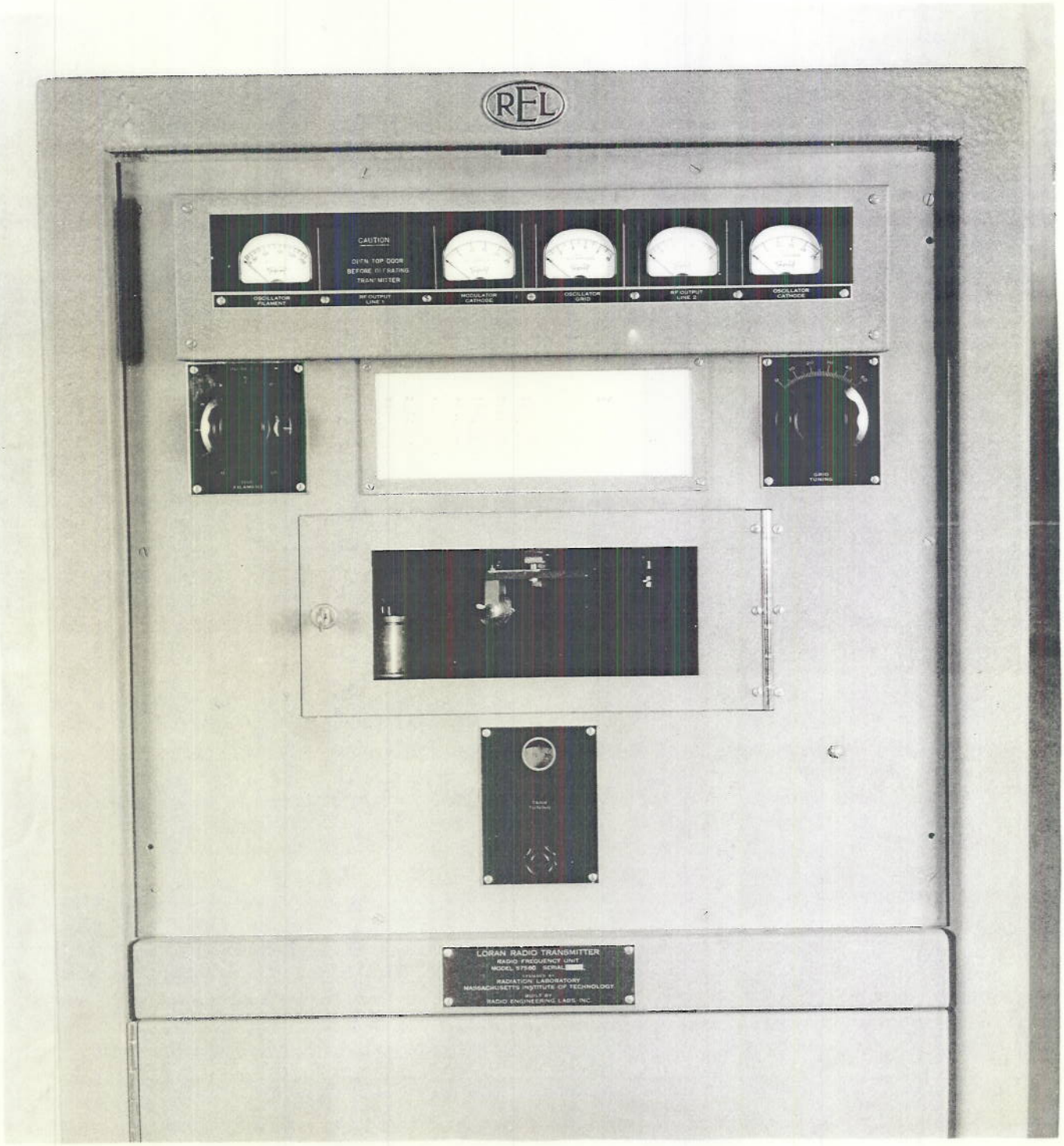

REL
CAUTION
OPEN TOP DOOR
BEFORE OPERATING
TRANSMITTER
OSCILLATOR FILAMENT
RF OUTPUT LINE 1
MODULATOR CATHODE
OSCILLATOR GRID
RF OUTPUT LINE 2
OSCILLATOR CATHODE
GRID TUNING
LORAN RADIO TRANSMITTER
RADIO FREQUENCY UNIT
MODEL 97560 SERIAL
DESIGNED BY
RADIATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
BUILT BY
RADIO ENGINEERING LABS. INC.

PLATE 14

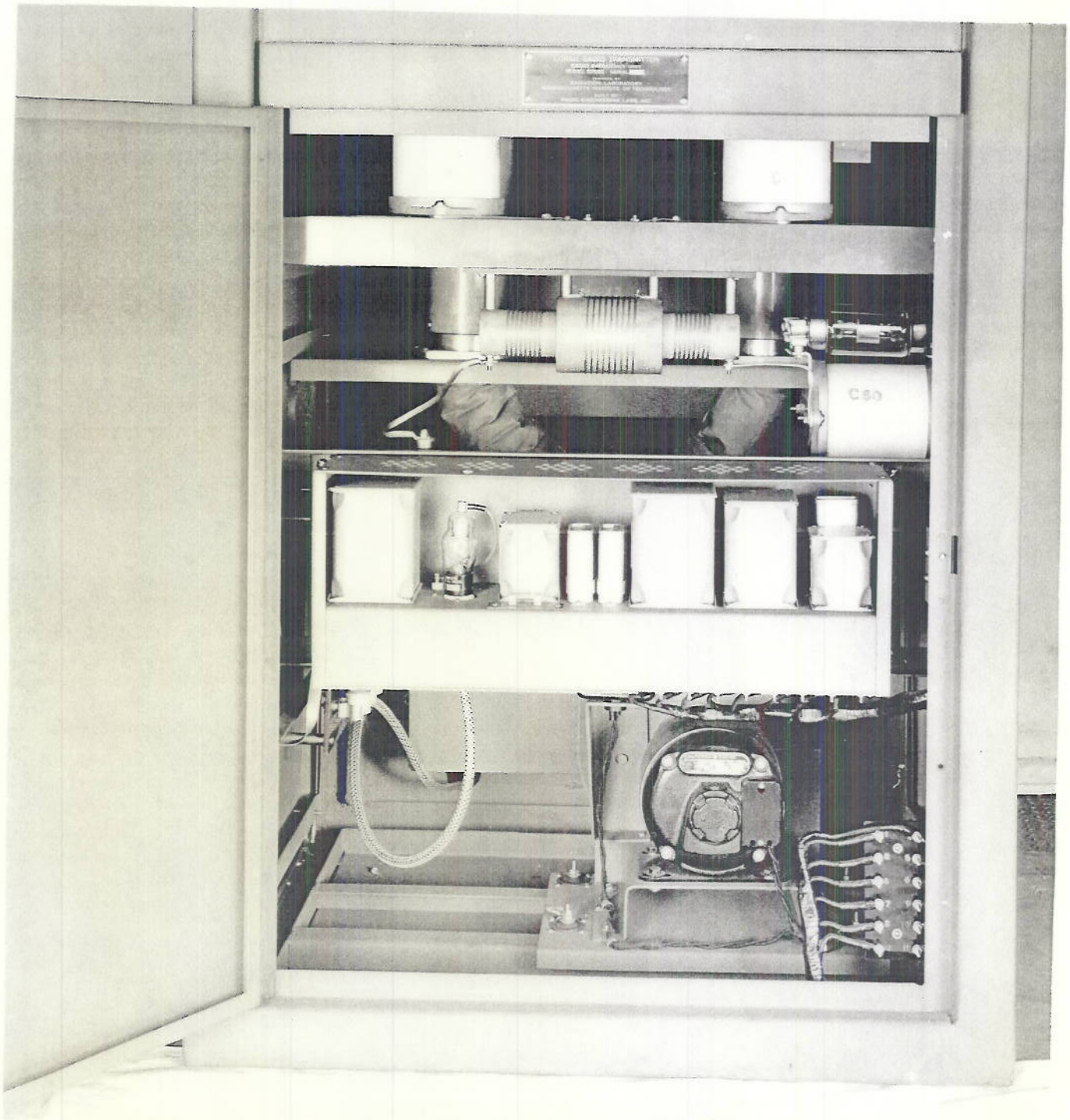


PLATE 15

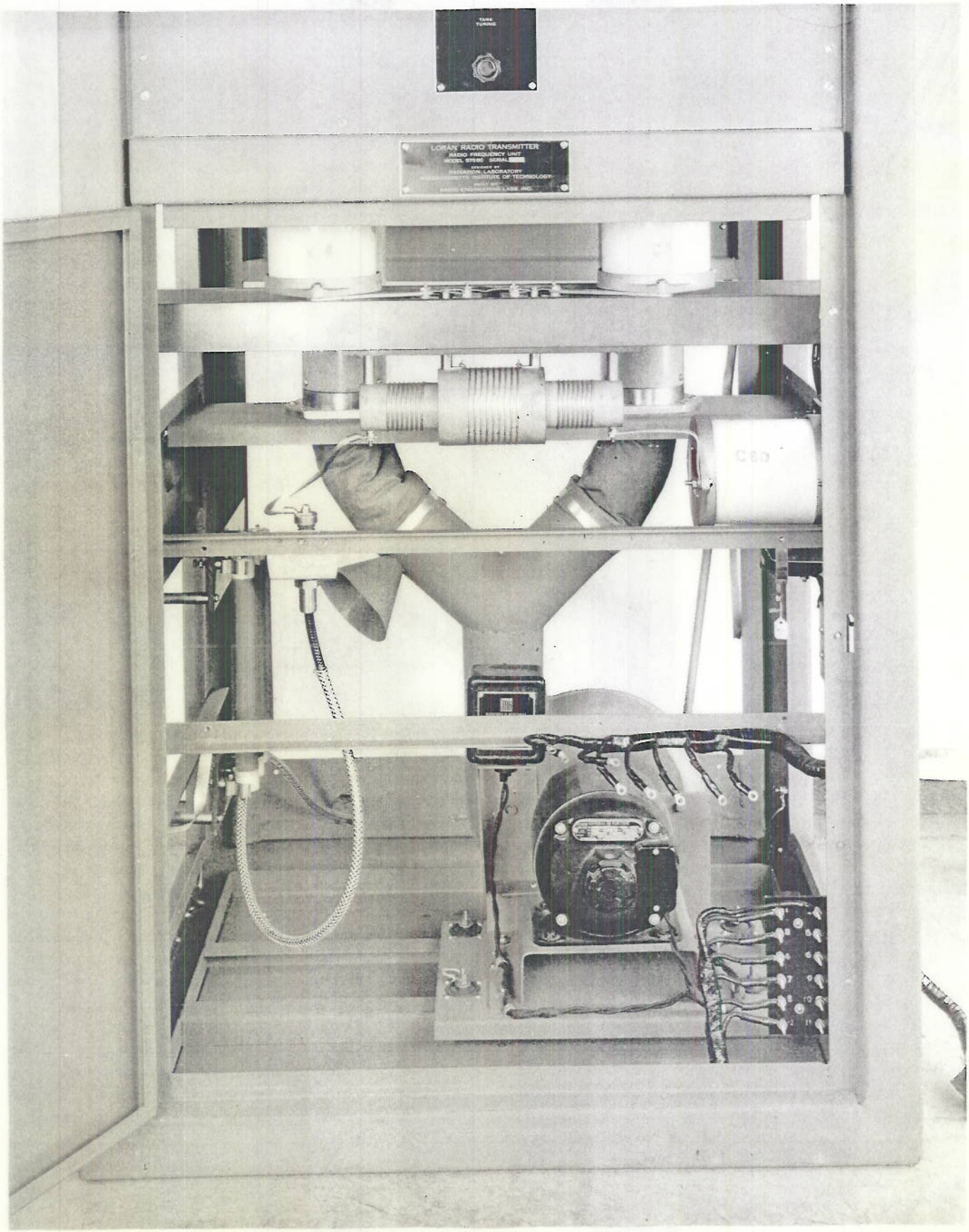

TUNE
TUNING
LORAN RADIO TRANSMITTER
RADIO FREQUENCY UNIT
MODEL 9930 SERIAL
DESIGNED BY
RADIATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
BUILT BY
RADIO ENGINEERING LABS. INC.

PLATE 16

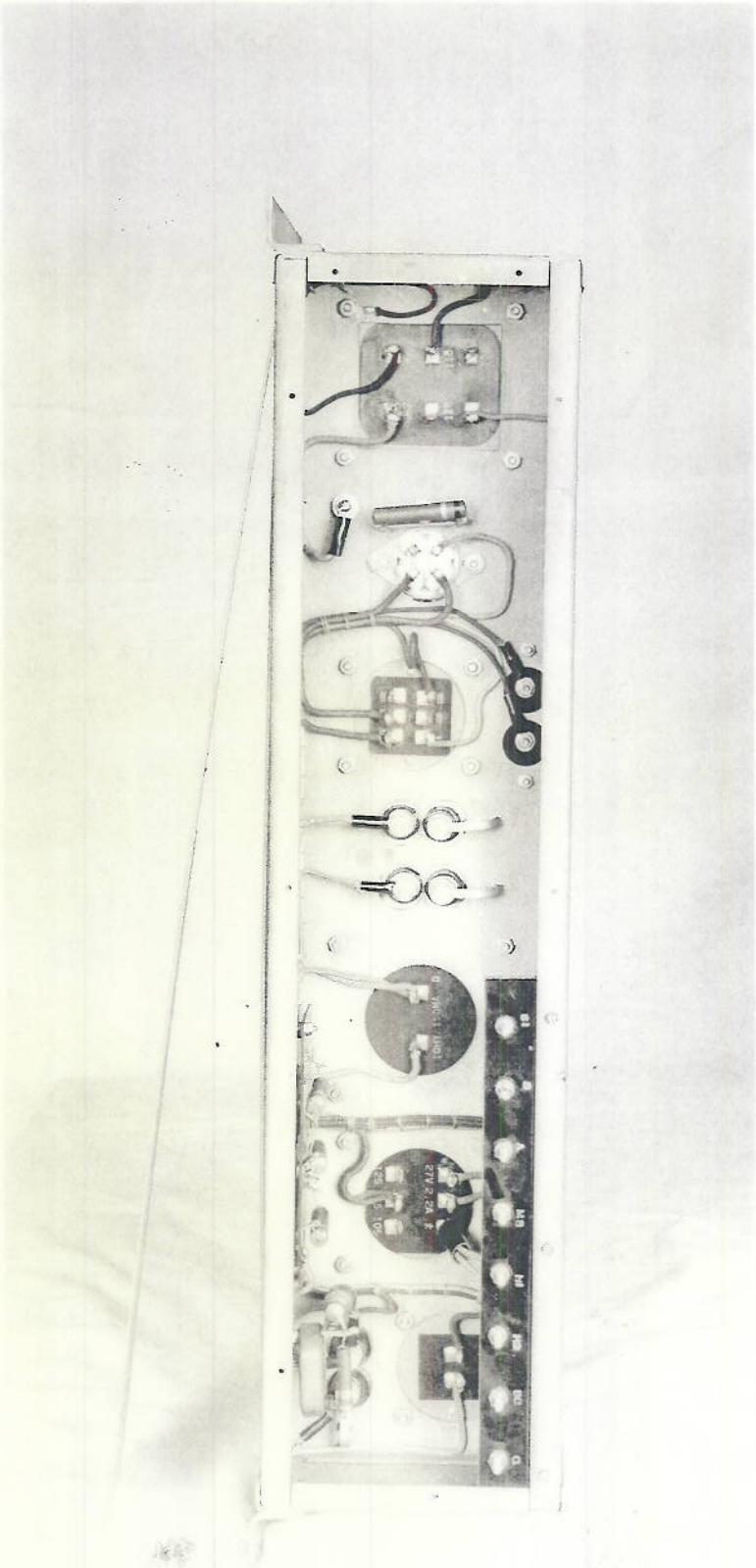


PLATE 17

PLATE 18

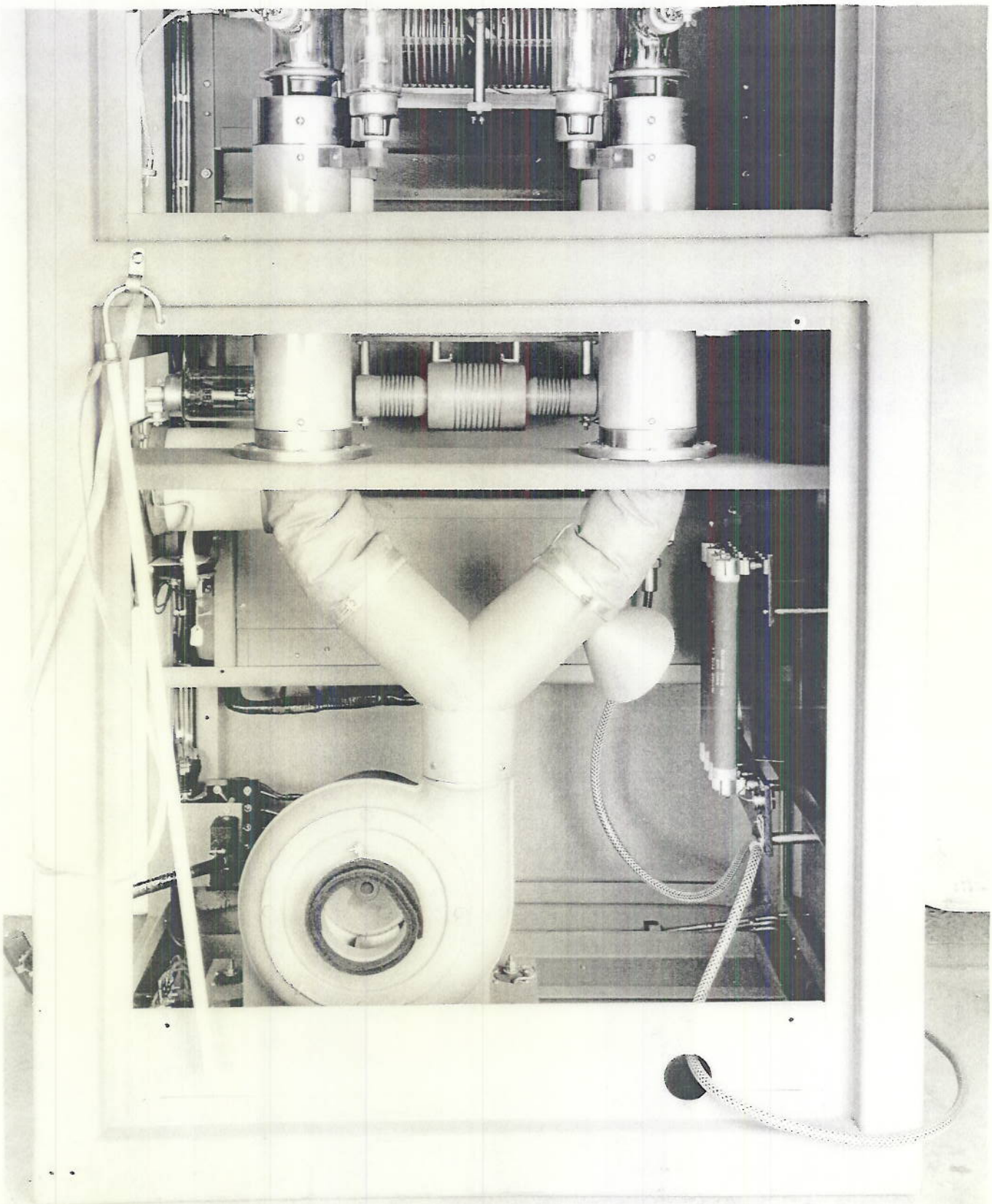


PLATE 19

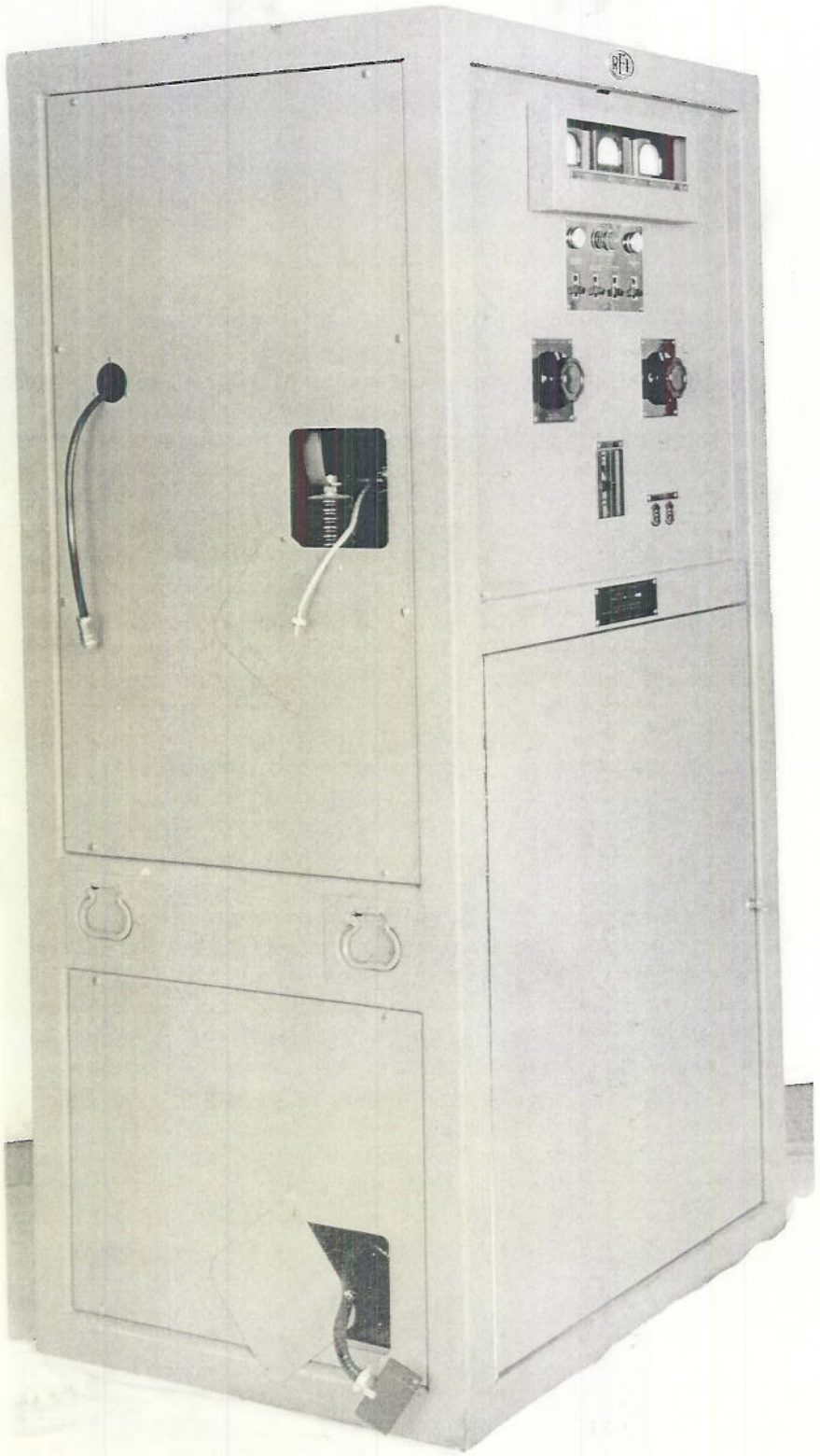


PLATE 20

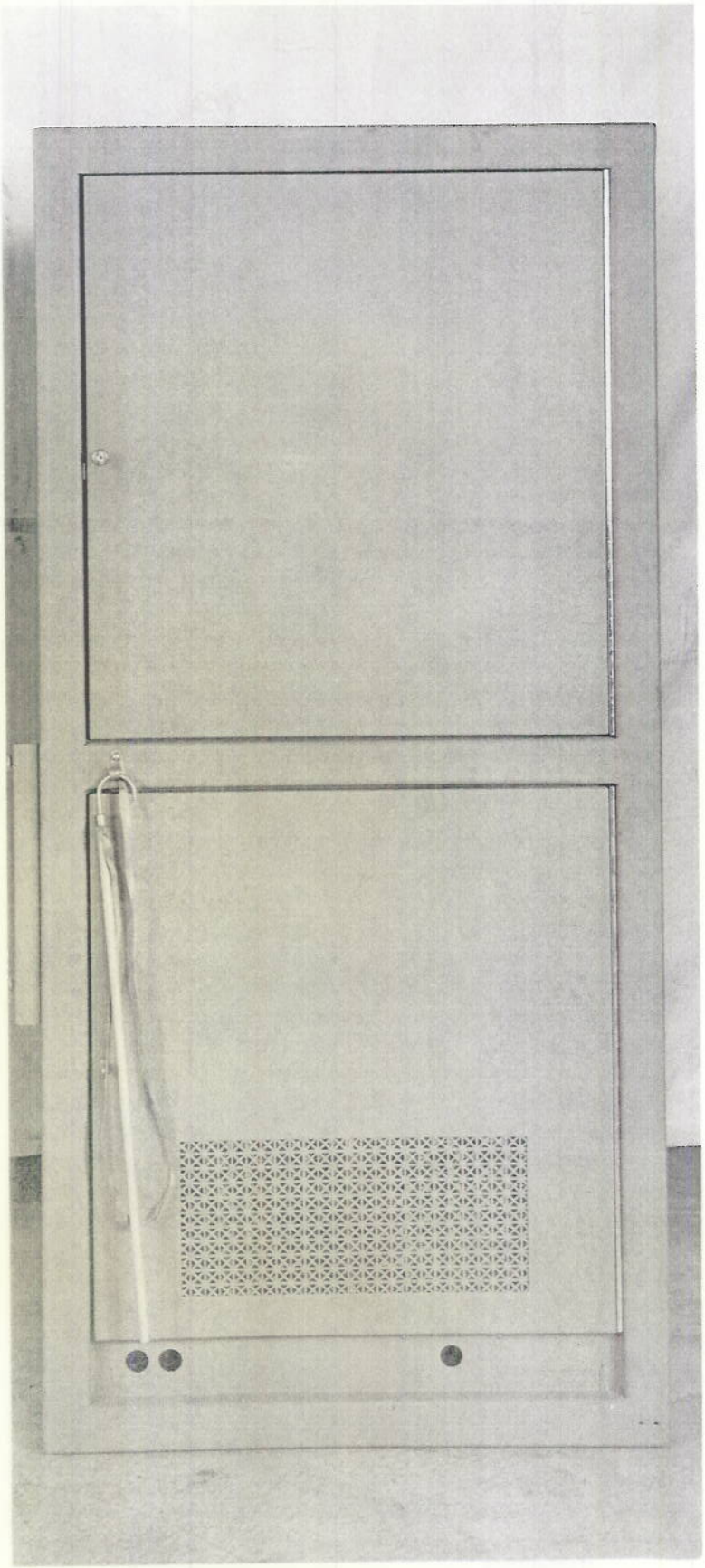


PLATE 21

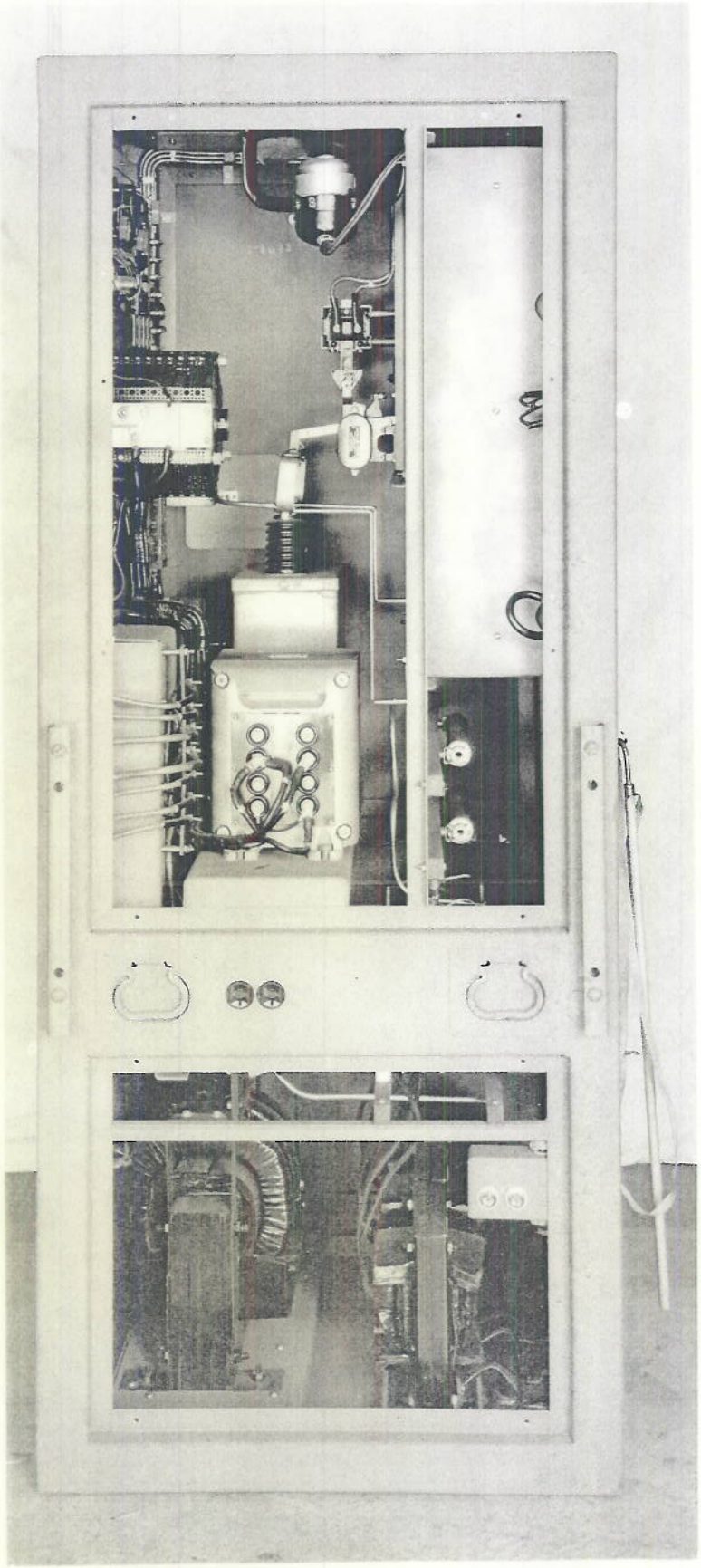


PLATE 22

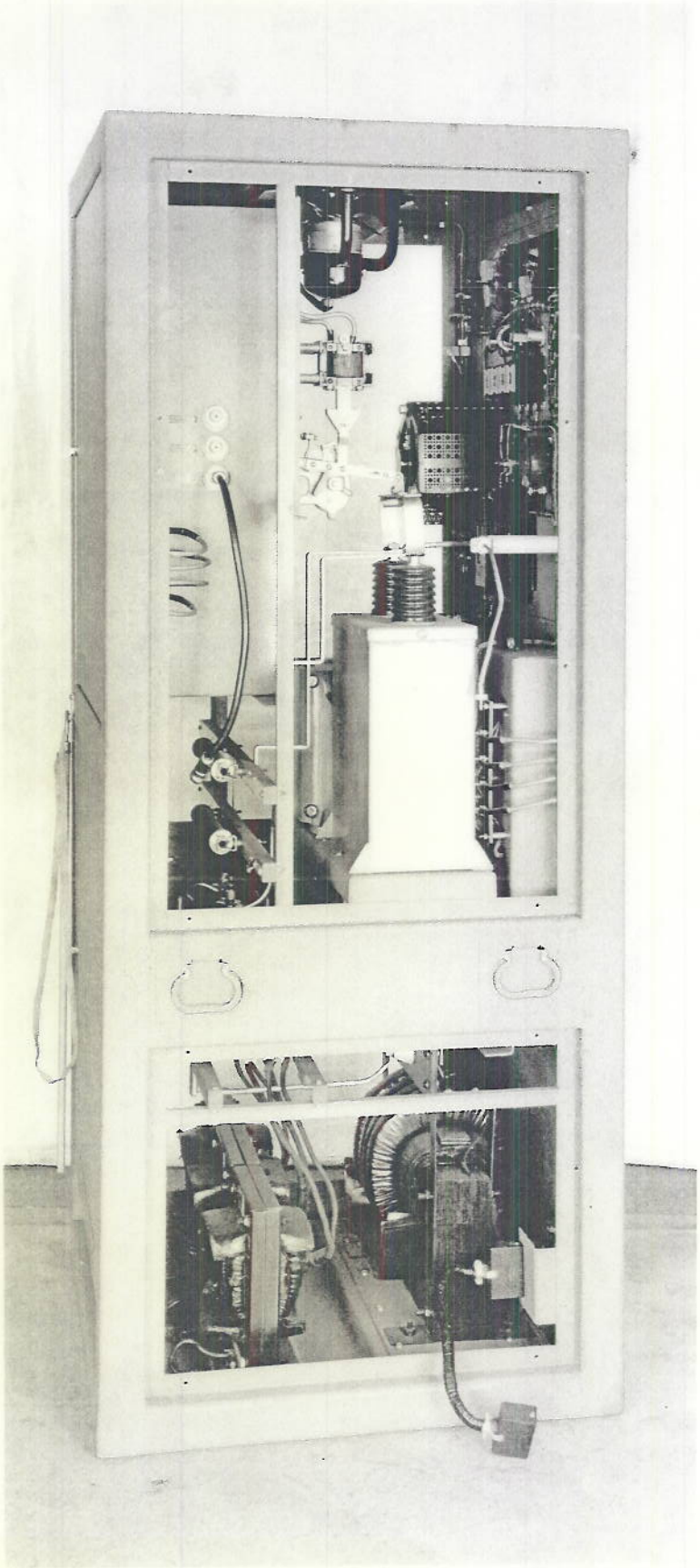


PLATE 23

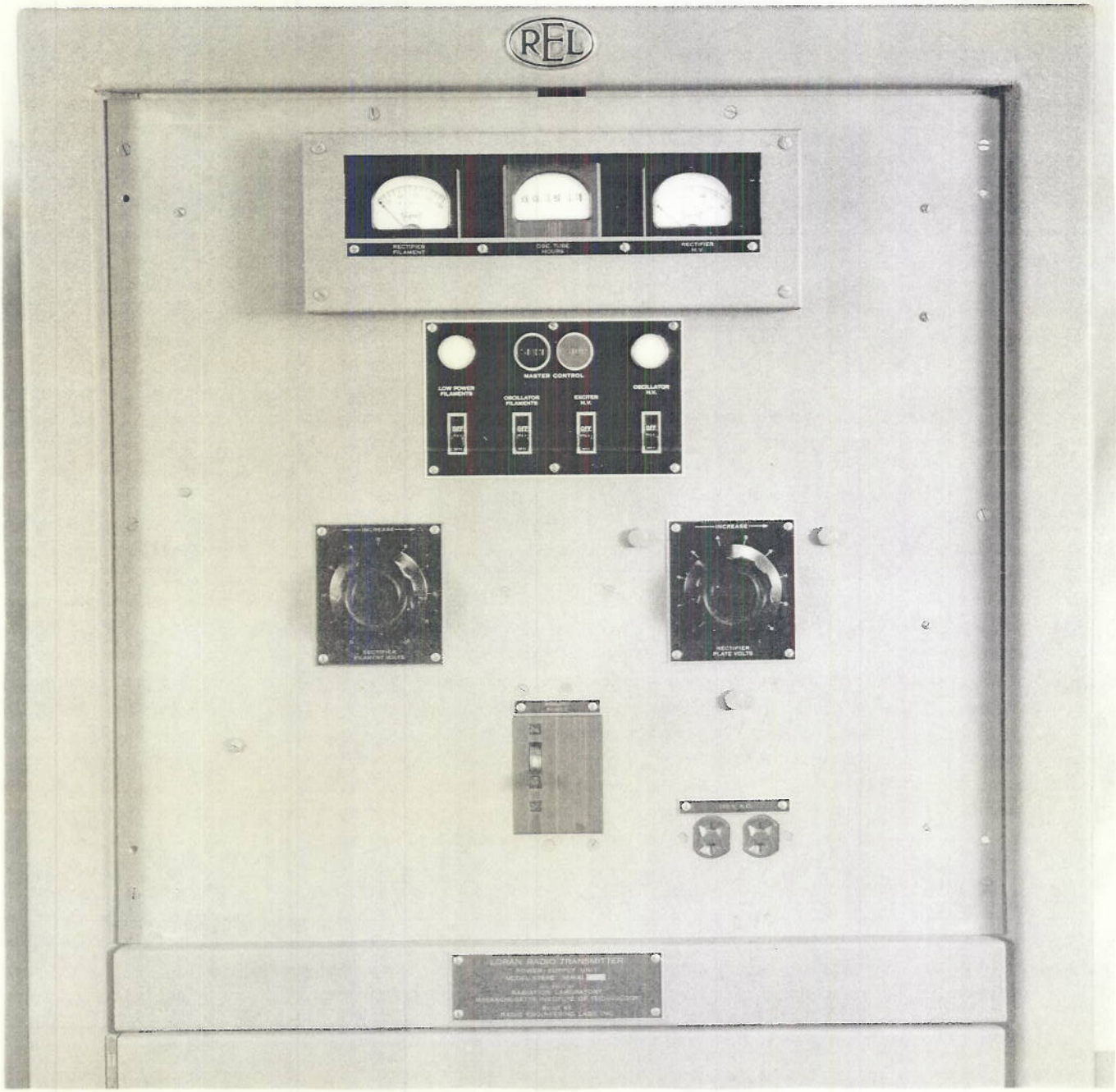

REL
RECTIFIER FILAMENT
OSC TUBE HOURS
RECTIFIER H.V.
MASTER CONTROL
LOW POWER FILAMENTS
OSCILLATOR FILAMENTS
EXCITER H.V.
OSCILLATOR H.V.
INCREASE
RECTIFIER PLATE VOLTS
LORAN RADIO TRANSMITTER

PLATE 24

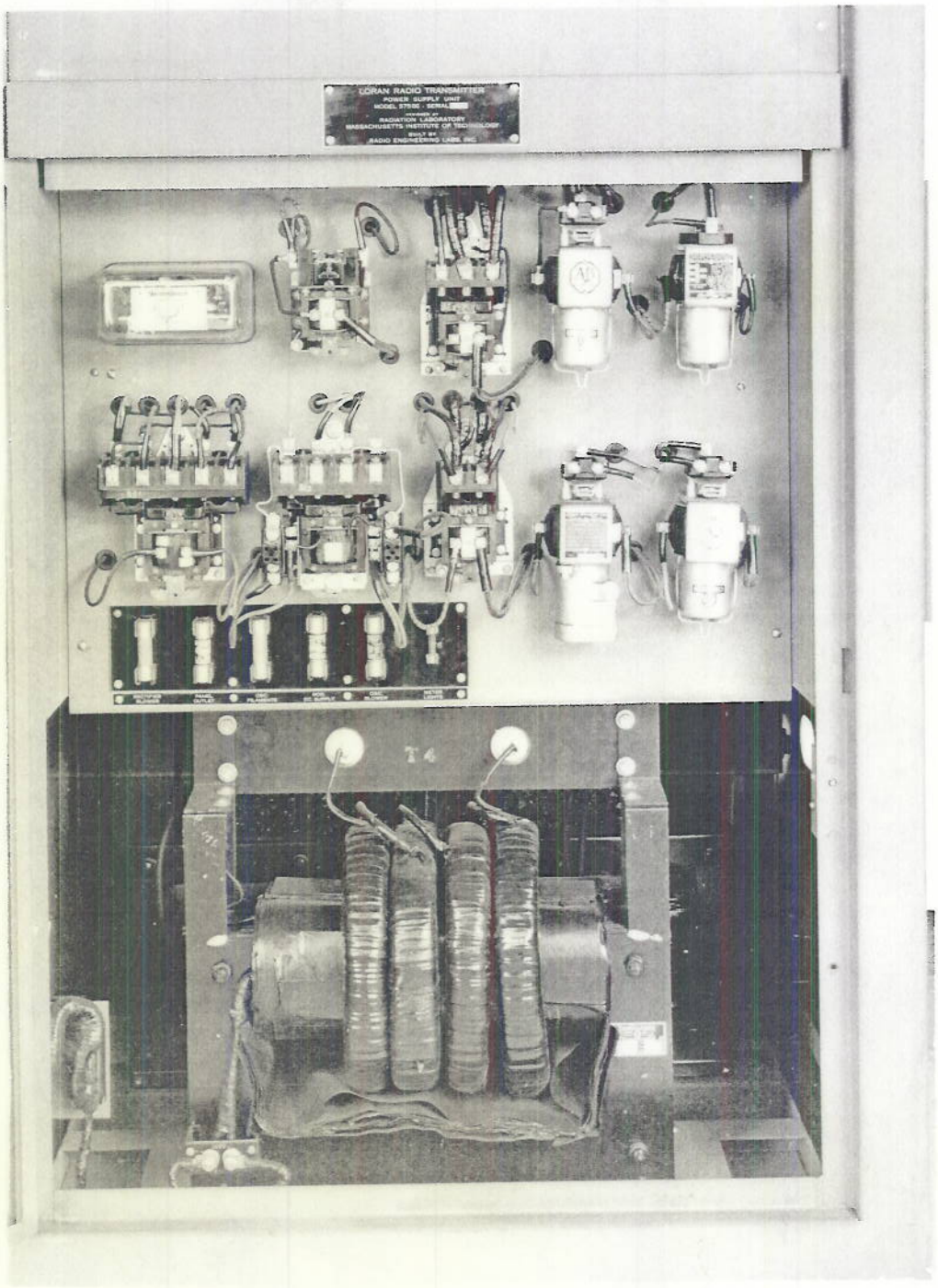

LORAN RADIO TRANSMITTER
POWER SUPPLY UNIT
RADIATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
BUILT BY
RADIO ENGINEERING LABS., INC.
T4

PLATE 25

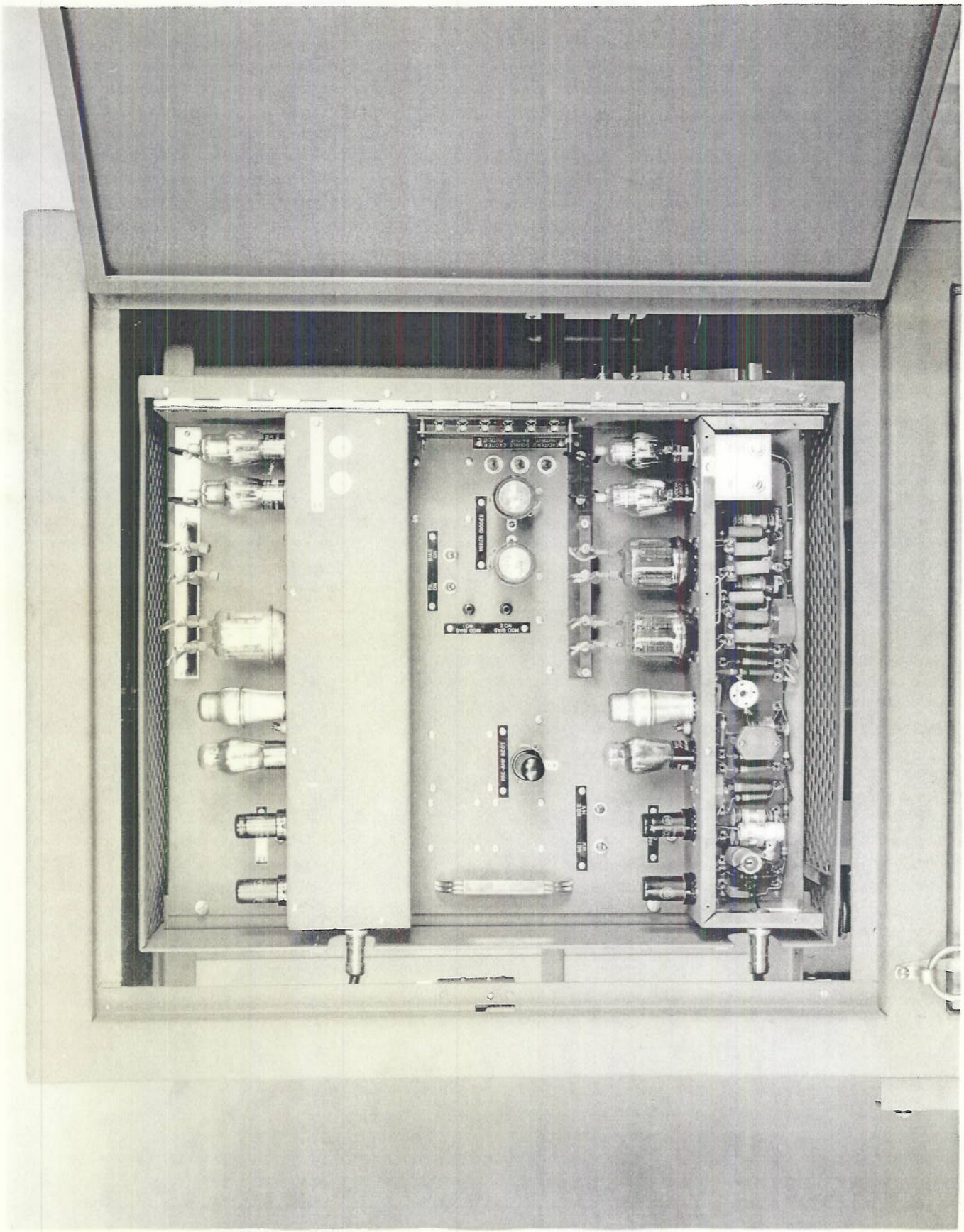


PLATE 26

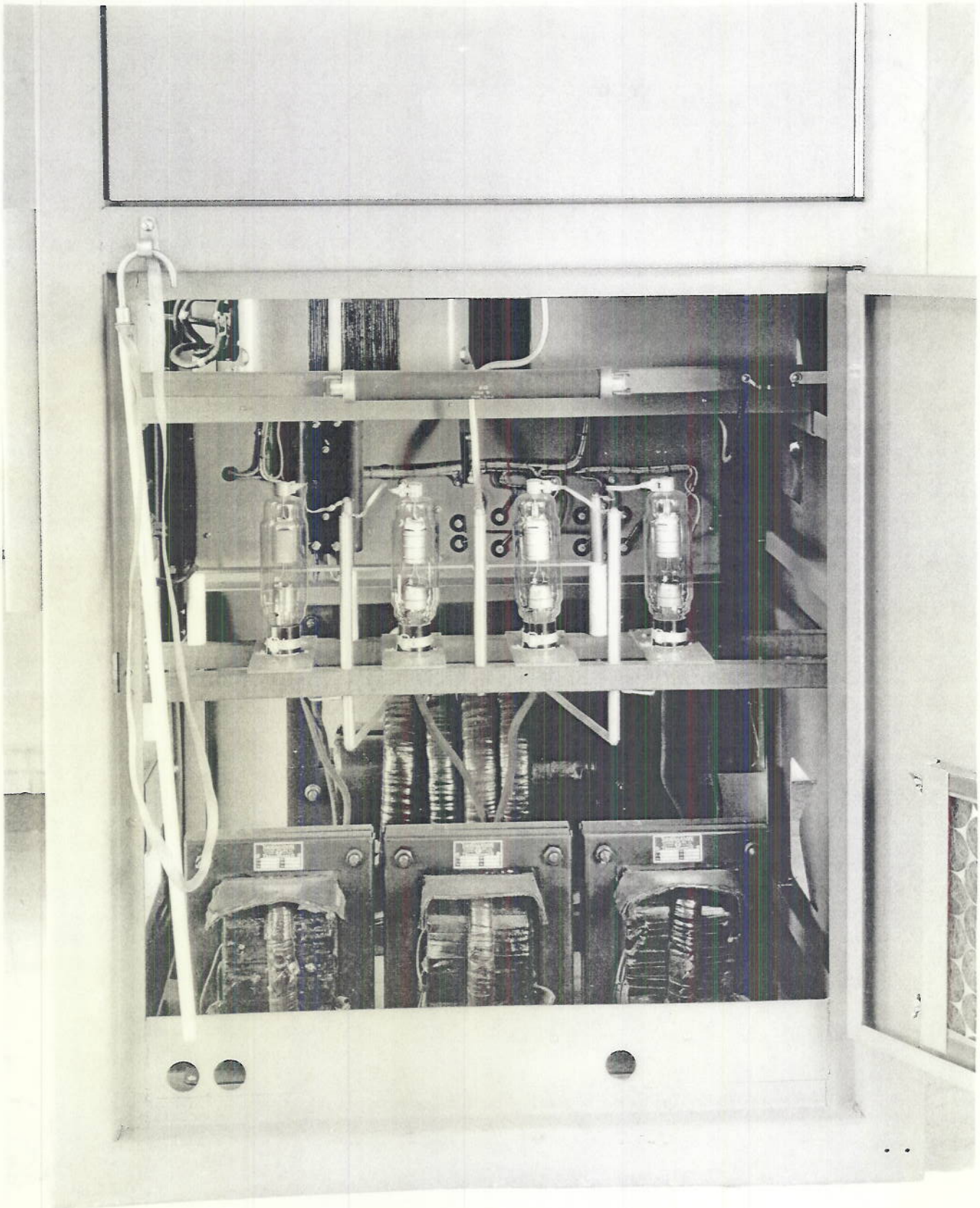


PLATE 27

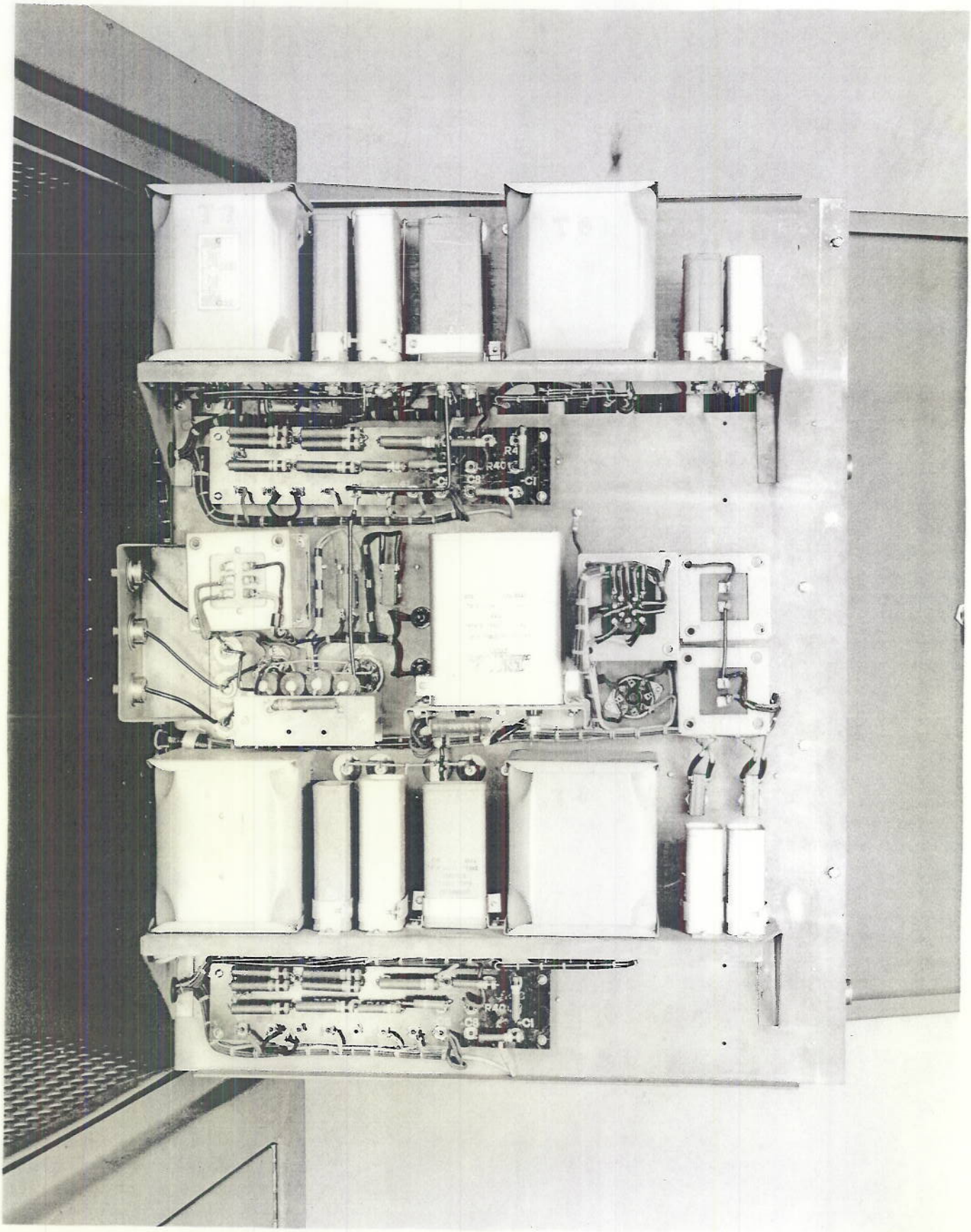


PLATE 28

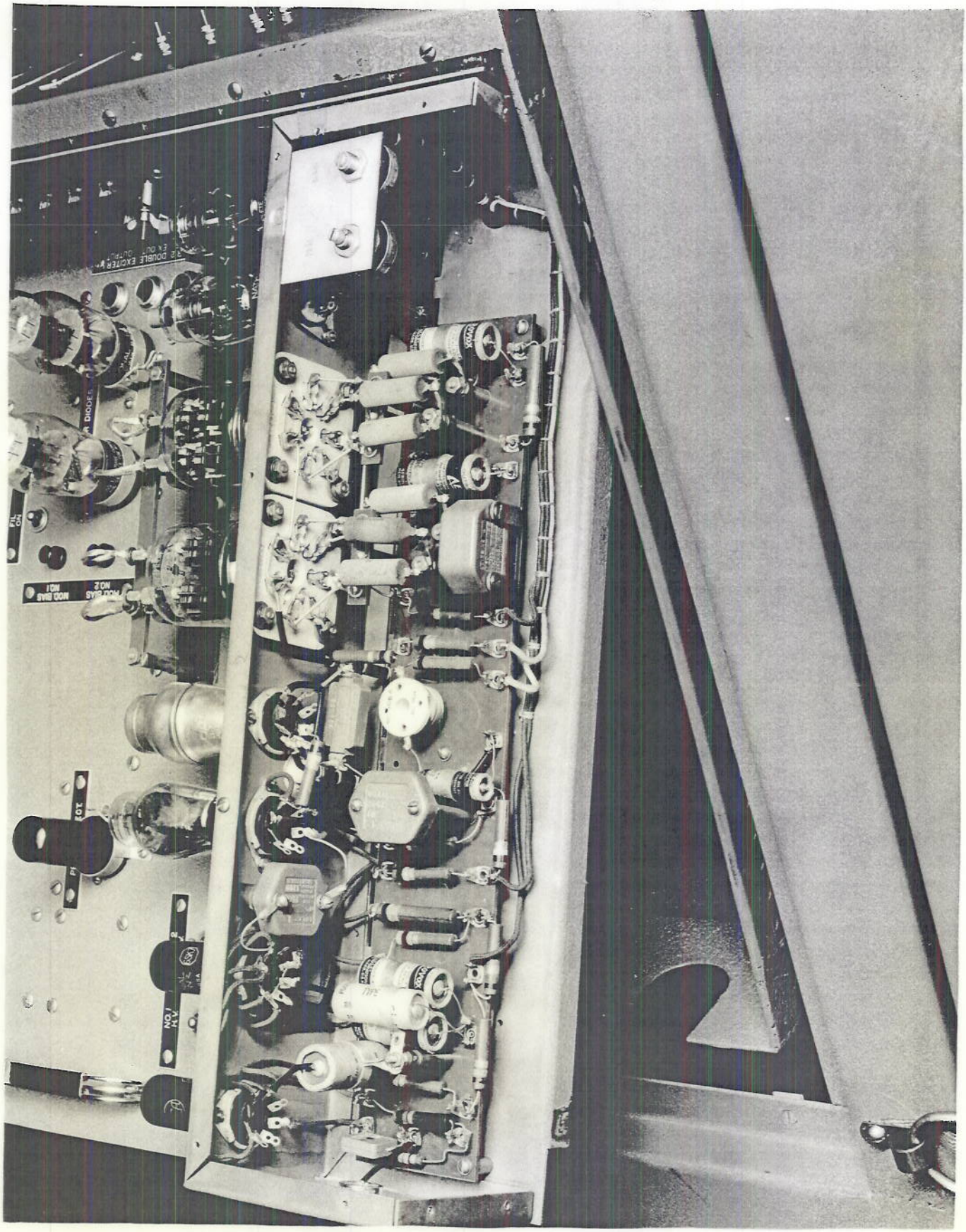


PLATE 29

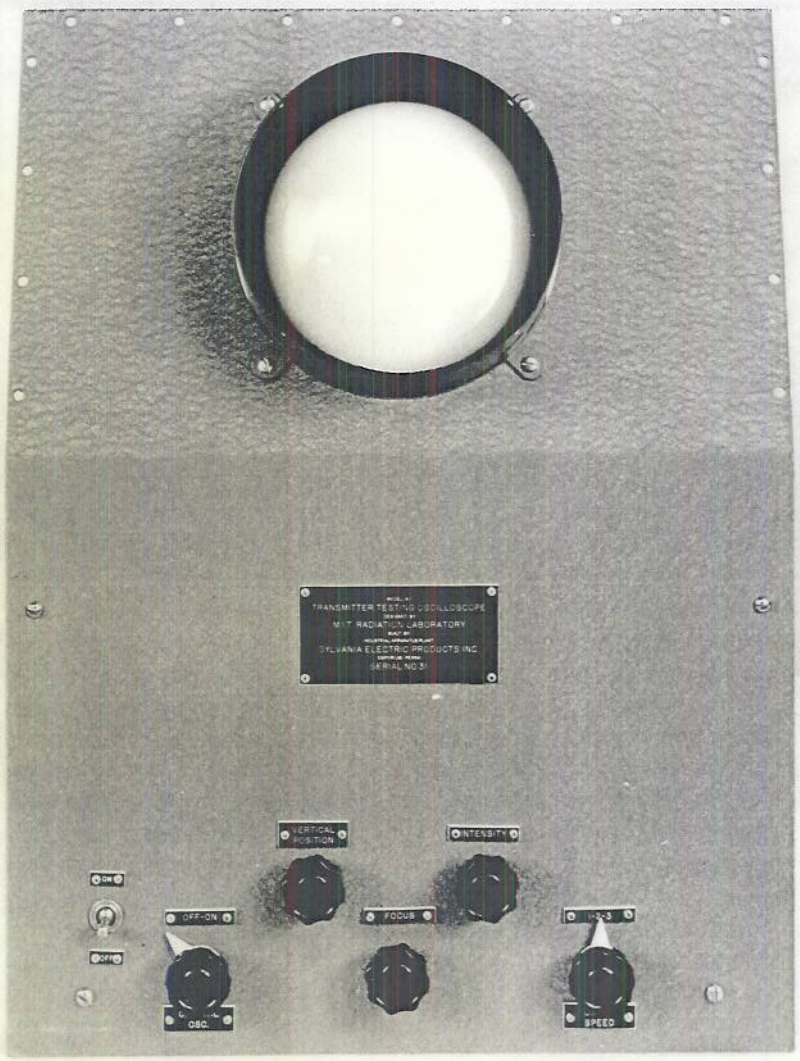

TRANSMITTER TESTING OSCILLOSCOPE
DESIGNED BY
M.I.T. RADIATION LABORATORY
BUILT BY
SYLVANIA ELECTRIC PRODUCTS INC.
SERIAL NO. 31
VERTICAL POSITION
INTENSITY
ON
OFF-ON
FOCUS
OFF
OSC.
SPEED

PLATE 30

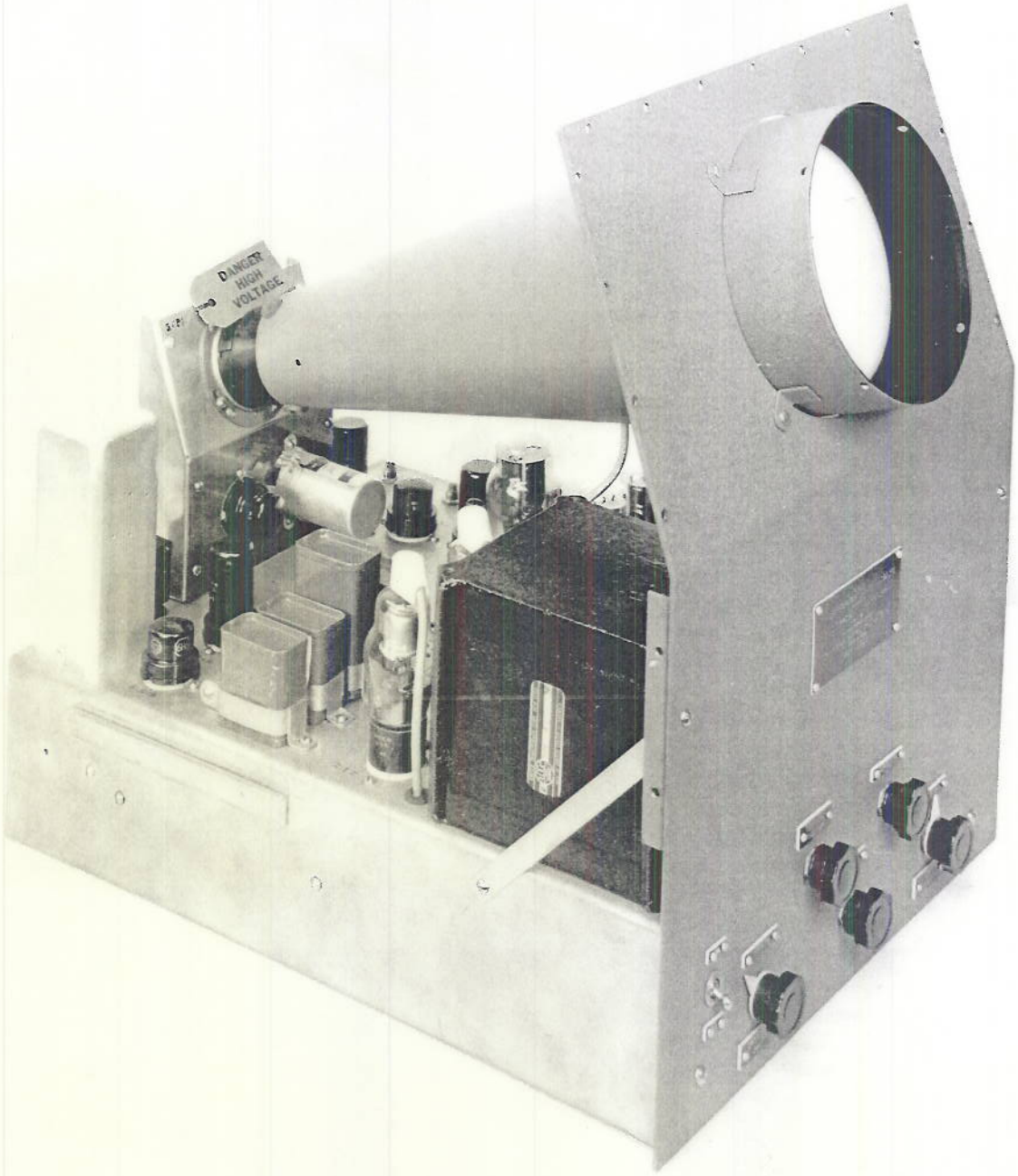


PLATE 31

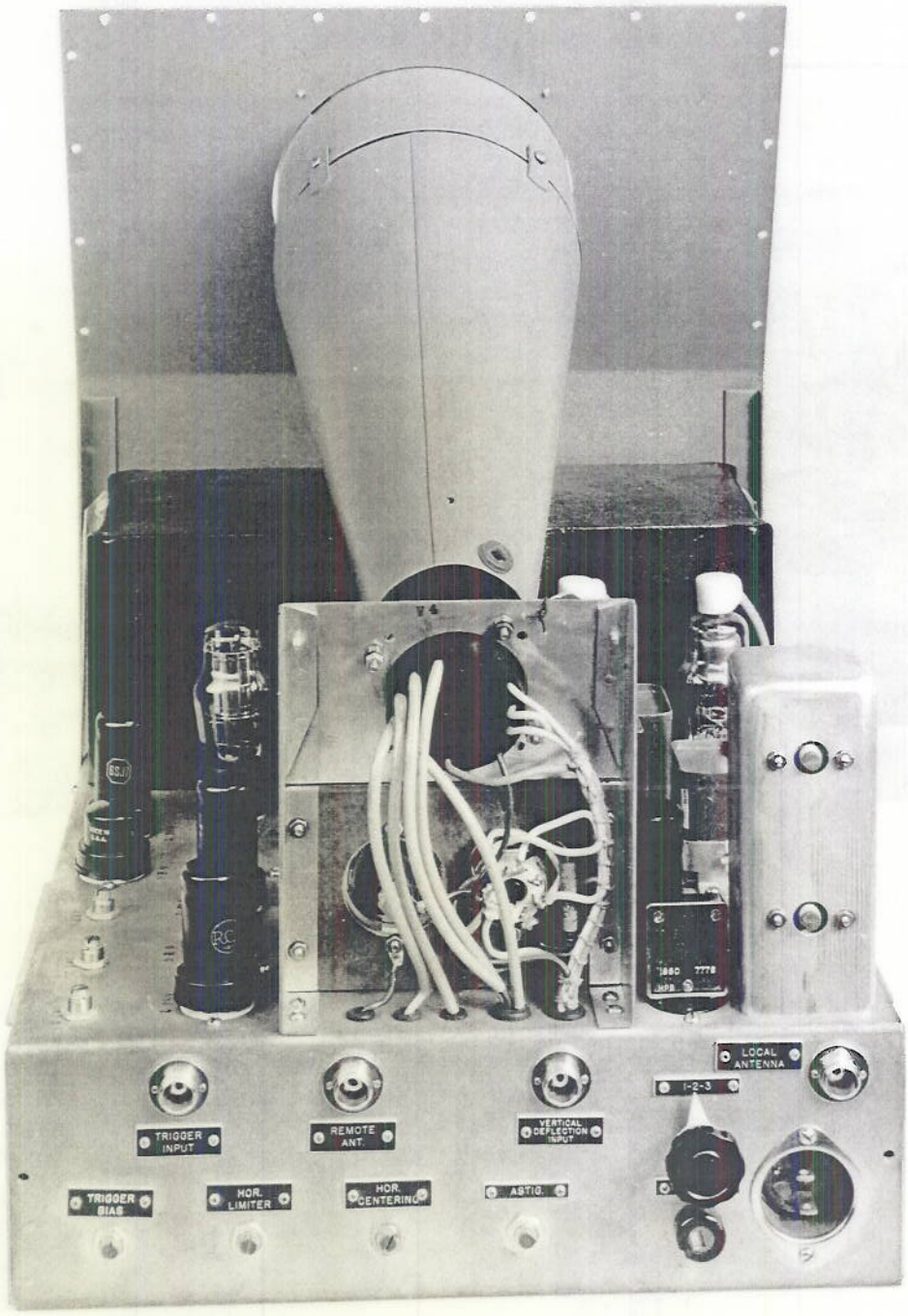

TRIGGER INPUT
REMOTE ANT.
VERTICAL DEFLECTION INPUT
LOCAL ANTENNA
1-2-3
TRIGGER BIAS
HOR. LIMITER
HOR. CENTERING
ASTIG.

PLATE 32



PLATE 33

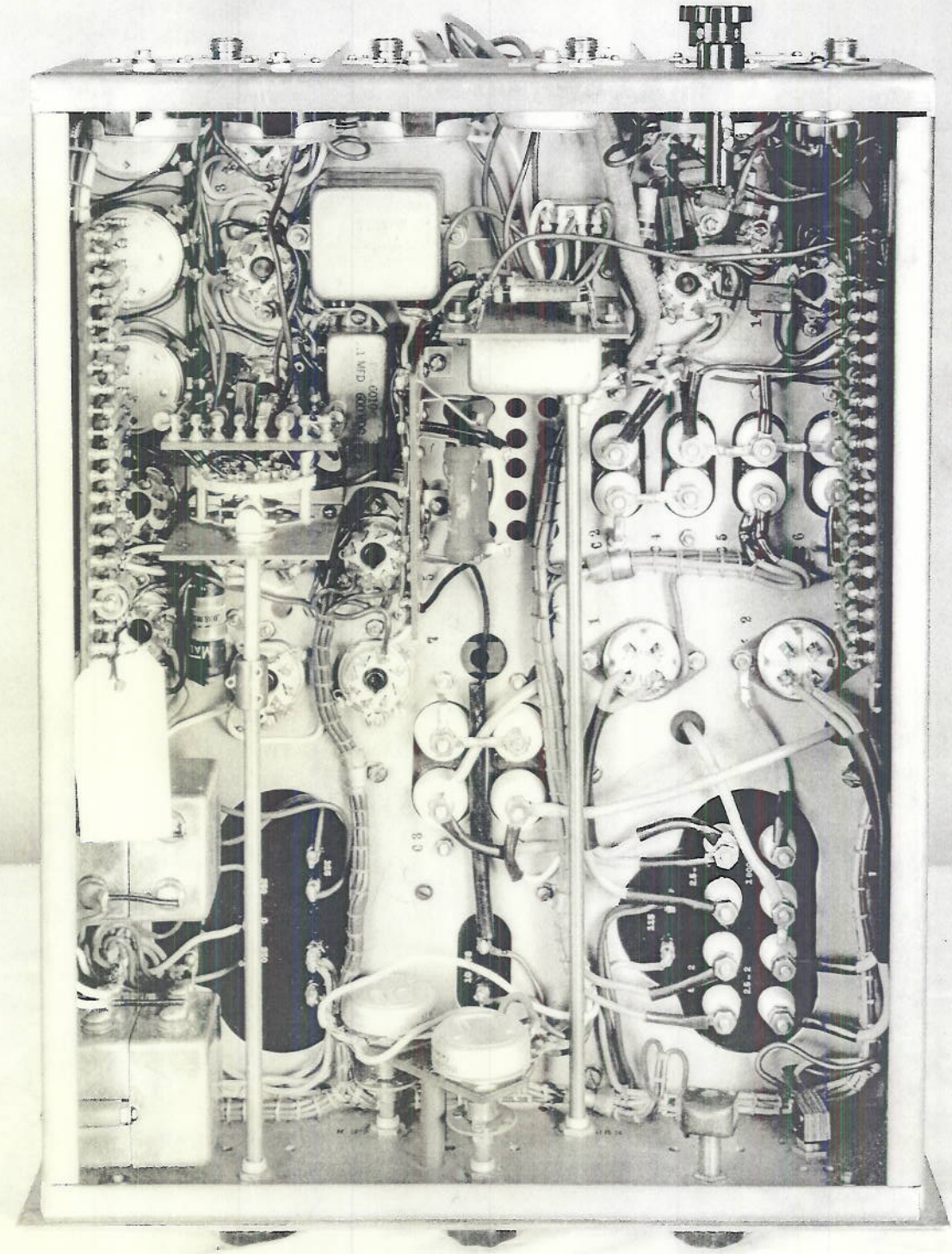


PLATE 34

APPENDIX A

DOUBLE PULSED OPERATION

1. Effect of Pulse Amplitude, Phase, and Shape on one rate when other pulse rate is blinking.

(a) The consideration of this subject is dependent upon the type of Loran Timer being employed to excite the transmitter. The B series Loran Timer "blinks" its output by the use of a cam-operated micro-switch which shorts the Timer output for a period of approximately 2/3 seconds followed by an "on" period of approximately 1-1/3 seconds. Consequently, when the transmitter is being double pulsed, blinking one pulse rate results in the partial "loading" and "unloading" of the transmitter so that during the "off" period of blinking with one Timer, the transmitter is effectively being single pulsed. Effectively, when blinking of one Timer occurs during double pulse operation, the transmitter is being alternately changed from single to double pulse operation. Blinking a Model B Timer during single pulse operation results in zero output from the transmitter during the 2/3 second Timer "off" period. The Model C Loran Timer accomplishes its blinking by placing the coding delay in a state of change for periods of time approximating those mentioned above. If the coding delay at a slave station employing a Model C Timer is 1000 microseconds, blinking results in the continuous variation of the coding delay between 1000 and a maximum of 4000 microseconds. Adjustment of the blinker shift control sets the limit within which the continuous coding delay variation is occurring. This adjustment is made in increments of 1000 microseconds to coincide with the 1000 microsecond locking pips provided to the delay multivibrator. The blinker shift control permits a maximum addition of three 1000 microsecond increments to the operating coding delay. This "blinking" or continuous change in the time delay makes it impossible for the navigator to obtain a fixed measurement of the time delay. It should be remembered throughout the following discussions that the essential difference in blinking the B and C Timers is that the B Timer results in a change from single to double pulsing while the C Timer simply effects a rapid phase change during which it continues to deliver output voltage. It should also be remembered that the purpose of blinking a Timer is to warn the Navigator or Loran chain operators that synchronization or equipment difficulties are occurring and any readings they might make are in error. Blinking a Master Station indicates improper rate, etc. to the Slave Operator warning him to blink his output. Blinking a Master Station might also indicate to the Slave Operator that the Slave Station is not operating in synchronism. Blinking at the Slave Station may mean that the Slave Operator is not receiving sufficient signal from the Master or that the Slave station is unable to keep synchronism. It is conceivable that the Model C Timer

blinker shift might be arranged in a code so that the thousand microsecond increments of blinker shift might mean certain difficulties.

(b) The effects upon pulse amplitude and shape under blinking conditions with a B Timer may be observed by reference to Plate 5. These photographs were taken of the Sylvania Al Testing Oscilloscope monitoring the transmitter output due to Exciter A while Exciter B was driven by a Model B Timer. Plate 5(A) was snapped during the 2/3 second "off" period of the B Timer while Plate 5(B) shows conditions during the "on" or double pulse period. Close examination reveals that during the "off" period the peak pulse amplitude rises about 2% while the lagging edge of the pulse increases about 21%. If the transmitter is being double pulsed with an oscillator plate potential of 17.5 kv, blinking the B Timer results in the plate voltmeter rising to 18.1 kv. A similar change in oscillator potential occurs with blinking under single pulse conditions. If the blinking is observed on the standard Loran receivers, an effect similar to a "phase shift" occurs in the usable pulse while the other rate is being blinked. Consequently if the unblinked rate is in use by the navigator he will observe a slow 2 to 3 microsecond "jitter" and will be unable to obtain the usual accurate superposition of pulses at the receiver. This effect is probably due to a combination of reasons Approximately 30 microseconds delay normally occurs in the timer, transmitter and timer receiver. This delay may be observed on the fast sweep of the timer oscilloscope since the leading edge of the pedestal generator triggers the fast sweep as well as the timer pulse which in turn triggers the transmitter. The delay in the circuits may be observed by noting the time from the start of the sweep to the point where the pulse appears on the trace. In view of this finite delay in the circuits it is probable that a shift in time occurs when the transmitter is effectively changing from single to double pulse operation as is the case in the blinking of the B Timer. This difficulty is due to changes of voltage in one or a combination of the following circuits: oscillator grid, oscillator plate, modulator screen, and modulator grid. Another factor which may be causing an apparent phase shift at the receiver during the blinking of a B Timer is the fact that since the transmitter oscillator is self-excited, the change in oscillator voltage will cause transient carrier frequency shifts during blinking. Since the receiver is set at a given frequency a change in frequency of the incoming signal will alter the shape of the pulse somewhat resulting in an apparent phase shift.

(c) Blinking a Model C Timer when the transmitter is being single pulsed has no apparent reaction on the transmitter. However, the blinker circuit on some Model C Timers is unstable and requires careful adjustment of the blinker shift control to insure continuous timer output during the blinking period. Unstable operation of the blinker results in zero output from the trans-

mitter for a small portion of a second if the transmitter is being single pulsed. Blinking a Model C Timer driving a double pulsed transmitter results in negligible transmitter reaction provided the blinker is stable and the pulses are at least 5000 microseconds on either side of cross-over. However, if the blinker shift is in excess of 2000 microseconds, an undesirable condition arises when approaching crossover. Plate 1 shows pulse amplitude differences near crossover. Considering the pulses in Plate 1, let us assume that the leading pulse is to be blinked resulting in its movement to the right crossing over the second pulse thereby causing it to lag for a few microseconds and causing the amplitude of the second pulse to increase since it would now be leading for a few microseconds. When the blinker shifts the pulse back to its original position another crossover will occur depending on the difference of rates between the leading and lagging pulse. It is evident that if the blinker shift is extended too far numerous cross-overs and near cross-overs will occur resulting in amplitude variations of the unblinked pulse rate when the other pulse rate is blinking in a double pulse system. It is therefore desirable to keep the period of blinker shift at 1000 microseconds to keep the transmitter reaction at a minimum during blinking. An exception to this rule would have to be granted if the blinker shift increments are employed in a code to transmit information on particular equipment difficulties.

2. Interaction of pulses at time of cross-over.

(a) If two frequencies differ from each other by 1/16 cycle it is evident that every 16 seconds the two frequencies must be in phase. Consequently, at this cross-over point the Timers would excite the transmitter simultaneously. Since the individual repetition rates differ, the effective repetition rate is constantly changing except at this cross-over point. This effect is accentuated prior to and following the cross-over point. To photograph the effects which occur, both Timers were set on the same rate so that the phase of one rate could be slowly changed with respect to the other by movement of the phasing control on one Timer. Photographs of the effects of this "slow motion" crossover were taken at various points in the cross-over cycle. Photographs of the cross-over were taken on the Sylvania Model A1 Transmitter Testing Oscilloscope, the Model C Timer Fast Sweep Monitoring Oscilloscope, the DAS-1 receiver-indicator Oscilloscope and the NRL Servo-CRO. The latter instrument was employed in view of the unlinear sweep of the Transmitter Test CRO shown in Plate 4(E). The sweep linearity of the NRL Servo-CRO may be observed by referring to Plate 4(F). Markers indicate the sweep linearity of the DAS-1 indicator as shown in Plate 4(G) while Plate 4(H) shows the Model C Timer Fast Sweep. Plates 1 to 5, inclusive, are photographic records of waveforms as seen on the various cathode ray oscilloscopes mentioned above. Throughout the following discussion it is well to remember that the frequency of the cross-overs is dependent upon the difference in rates. The minimum number of cross-overs is experienced when

both timers are on adjacent rates so that a cross-over occurs every 16 seconds. The maximum number of cross-overs would be obtained with one timer on rate 0 and the second timer on rate 7 when a cross-over occurs every 2-2/7 seconds.

(b) Reference to Plates 1 to 3, inclusive, shows that under double pulse operation the pulses are in a constant state of amplitude change depending on their position in the cross-over cycle. Plate 5)A) shows the transmitter output waveform when the transmitter is being single pulsed. At the basic 0 rate of 25 cycles this means a period of 40,000 microseconds between pulses. Plate 3 (u) to (x) shows waveforms of single pulsing. If the transmitter is double pulsed by two timers, each on rate 0, the transmitter is effectively pulsed at a repetition rate of 50 with 20,000 microseconds between pulses if all pulses are equidistant. The transmitter output waveform under this condition may be observed by reference to 5(B). Plate 4(A) to (D) exhibits double pulse waveforms with an interval of 20,000 microseconds of time elapsing between pulses. It is at this point of equal time between pulses that the pulse amplitudes are equal. At all other positions of the cross-over cycle the pulses are of unequal amplitudes, the pulse of greater amplitude being the one following the longer idle interval since the previous pulse. Energy for the radio frequency oscillations is derived almost entirely from that stored in the capacitor C13 of the transmitter. During the quiescent period between pulses, C13 is charged through R4 from C1. If the length of the quiescent period varies, likewise, the potential of C13 for use during the pulse will also vary. As the cross-over is being approached the quiescent time approaches zero and the amplitude difference of the pulses is a maximum. To illustrate this effect, Plates 1 to 3, inclusive, were made beginning 200 microseconds before cross-over and concluding with the moment of cross-over when both exciters are keying simultaneously and the effective repetition rate is the same as though only one exciter were keying.

(c) Reference to Plate 3(q) to (t) shows a trifle more output with double pulsing at the exact moment of cross-over in comparison with Plate 3(u) to (x) under single pulse conditions. Plate 2(m) to (p) is a photographic record of the maximum pulse length obtained during the cross-over process. It should be remembered that a very rapid amplitude change occurs immediately after each cross-over. For purposes of discussion let us assume that the pulse on the left side of the screen in Plates 1 to 3, inclusive, is pulsing at rate 0 while the pulse on the right side of the screen is on rate 1. The transmitter output on rate 0 is then greater than the amplitude of output on rate 1 as cross-over is approached, the amplitude difference between the two being the greatest just immediately before cross-over. At the exact point of cross-over a navigator observing rate 0 will see the same pulse as a navigator working on rate 1. However, as far as the navigator's eye is concerned this action would seem to occur almost

instantaneously. The effect which is most apparent to the navigator is the sudden change in amplitude of the pulse under observation. This is due to the fact that immediately after cross-over rate 1 is leading rate 0 in the same manner as rate 0 was leading rate 1 just before cross-over. This means that the amplitude of rate 0 is varying from maximum to minimum in a period of about 50 microseconds while during the same period the amplitude of rate 1 is changing from minimum to maximum. The increment of this apparent instantaneous amplitude change is of the same value as the amplitude differences observed in Plate 1 (e) to (h). As a consequence of the transmitter reaction to double pulsing, the navigator observed a small continuous variation in amplitude of the pulse under observation until he notes another pulse sweeping through almost instantaneously at cross-over leaving the pulse under observation with an appreciable increase or decrease in amplitude depending on which rate is synchronized and under observation. Needless to say, this effect is annoying to the navigator.

(d) Plate 1 (a) might lead an observer to suspect that there is a difference in pulse length and shape as cross-over is approached. However, since the sweep of the Model A1 Monitoring Oscilloscope is unlinear as shown in Plate 4(E), photographs of the same condition were also taken with the NRL Servo-CRO as shown in Plate 1 (b). It should be observed that there is no appreciable change in pulse length or shape near corss-over. The change is largely an amplitude change as described above.

3. Power Output.

(a) Data on single and double pulse power output may be found by referring to Table 1.

(b) Measurements indicated that the rectifier output voltmeter was considerably in error. Table 1 contains data on differences in meter reading with respect to a Laboratory meter. A measurement of the multiplier resistors, R6, revealed that one had a resistance of 16.4 megohms and the other 15.1 megohms. This probably accounts for most of the meter error. The multipliers are of the carbon type with ±10% tolerances They also have the characteristic of increasing resistance with age as well as an increase in resistance with current flow. These effects would result in having the meter indicate a potential value below the actual value. It is suggested that these multipliers be replaced with a high quality wire-wound type of multiplier used in conjunction with a relaible 0-1 milliameter movement.

(c) Attention is directed to paragraph 3-22 of Specifications RE 13A 682B for Radio Pulse Transmitting Equipment requir-

ing 100 kilowatts peak power output into a 50 ohm non-inductive resistor load, single pulsed, with 17000 volts d-c plate voltage. A power output of 125 kilowatts peak is additionally required to be made available by increasing the oscillator plate voltage. Reference to Table 1 will show that these specifications requirements have not been fulfilled.

APPENDIX

TABLE 1

LORAN 575-BC TRANSMITTING EQUIPMENT

POWER OUTPUT

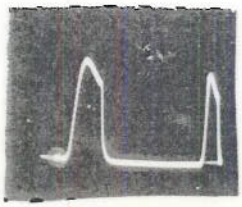
Osc. H. V. (Lab. Meter)	Osc. H. V. (575-BC Meter)	Osc. Cath. (Ma.)	Mod. Cath. (Ma.)	Avg. Power (Watts)	Peak Power (Kw.)
		Single Pulse (Note 1)			
20.0 Kv.	18.0 Kv.	17.0	9.4	80.75	80.75
17.5 Kv.	15.8 Kv.	15.1	9.2	58.30	58.30
15.0 Kv.	13.8 Kv.	13.1	8.8	38.40	38.40
		Double Pulse (Note 2)			
20.0 Kv.	18.0 Kv.	21.4	17.3	126.00	63.00
17.5 Kv.	15.8 Kv.	19.2	16.7	99.40	49.70
15.0 Kv.	13.8 Kv.	16.9	16.2	64.40	32.20

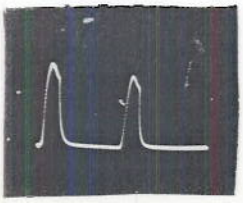
Note 1: The Transmitter was single pulsed at rate 0.

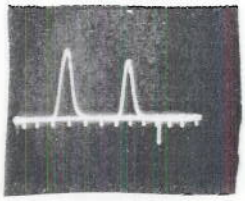
Note 2: The Transmitter was double pulsed at rate 0 with the pulses 20,000 microseconds apart resulting in an effective repetition rate of 50.

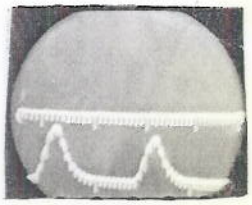
Note 3: The Transmitter was operating on a carrier frequency of 1850 Kilocycles.

Note 4: Specification requirements on power output may be found by referring to Paragraph 3-22 of Specifications RE 13A 682B covering Radio Pulse Transmitting Equipment.









DOUBLE PULSING 200 MICRO-SECONDS BEFORE CROSSOVER

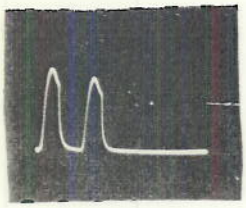
(a)MODEL A1 TRANSMITTER TESTING CRO. SWEEP #2.

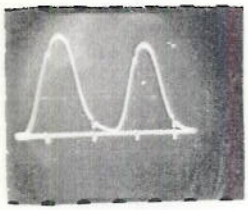
(b)NRL SERVO-CRO. 400 MICRO-SECOND SWEEP

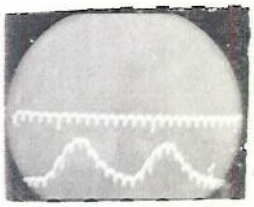
(c)DAS-1 RECEIVER. FAST SWEEP #2. 50 MICRO-SECOND MARKERS.

(d)MODEL C TIMER. FAST SWEEP #2. 10 AND 100 MICRO-SECOND MARKERS.









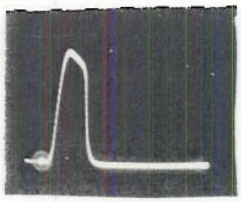
DOUBLE PULSING 100 MICRO-SECONDS BEFORE CROSSOVER

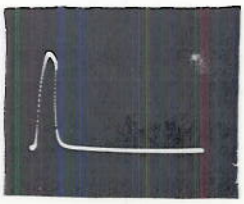
(e)MODEL A1 TRANSMITTER TESTING CRO. SWEEP #2.

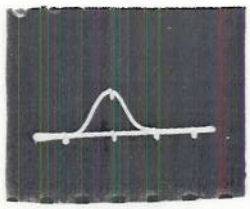
(f)NRL SERVO-CRO. 400 MICRO-SECOND SWEEP.

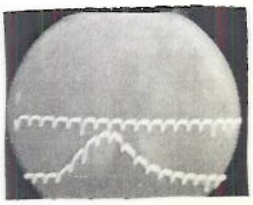
(g)DAS-1 RECEIVER. FAST SWEEP #1. 50 MICRO-SECOND MARKERS.

(h)MODEL C TIMER. FAST SWEEP #2. 10 AND 100 MICRO-SECONDS MARKERS.









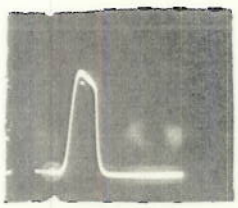
DOUBLE PULSING AT EXACT MOMENT OF CROSSOVER

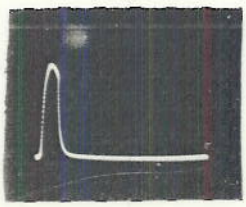
(q)MODEL A1 TRANSMITTER TESTING CRO. SWEEP #2.

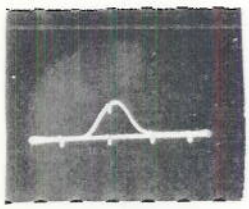
(r)NRL SERVO-CRO. 400 MICRO-SECOND SWEEP

(s)DAS-1 RECEIVER. FAST SWEEP #1. 50 MICRO-SECOND MARKERS.

(t)MODEL C TIMER. FAST SWEEP #2. 10 MICRO-SECOND MARKERS.









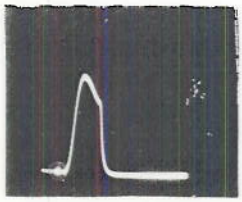
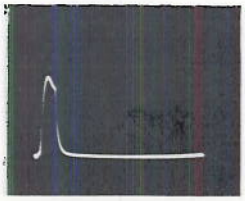
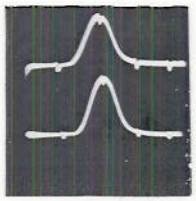
SINGLE PULSING

(u)MODEL A1 TRANSMITTER TESTING CRO. SWEEP #2.

(v)NRL SERVO-CRO. 400 MICRO-SECOND MARKERS.

(w)DAS-1 RECEIVER. FAST SWEEP #1. 50 MICRO-SECOND MARKERS.

(x)MODEL C TIMER. FAST SWEEP #2. 10 MICRO-SECOND MARKERS

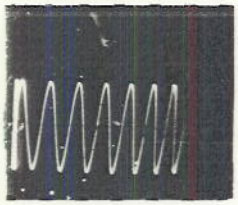
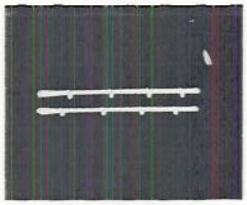
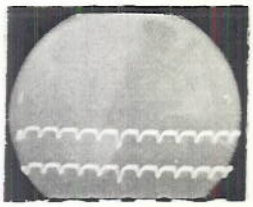

DOUBLE PULSING WITH AN INTERVAL OF 20,000 MICRO-SECONDS BETWEEN PULSES

(A)MODEL A1 TRANSMITTER TESTING CRO. SWEEP #2.

(B)NRL SERVO-CRO. 400 MICRO-SECOND SWEEP

(C)DAS-1RECEIVER. FAST SWEEP #1. 50 MICRO-SECOND MARKERS.

(D)MODEL C TIMER. FAST SWEEP #2. 10 MICRO-SECOND MARKERS.

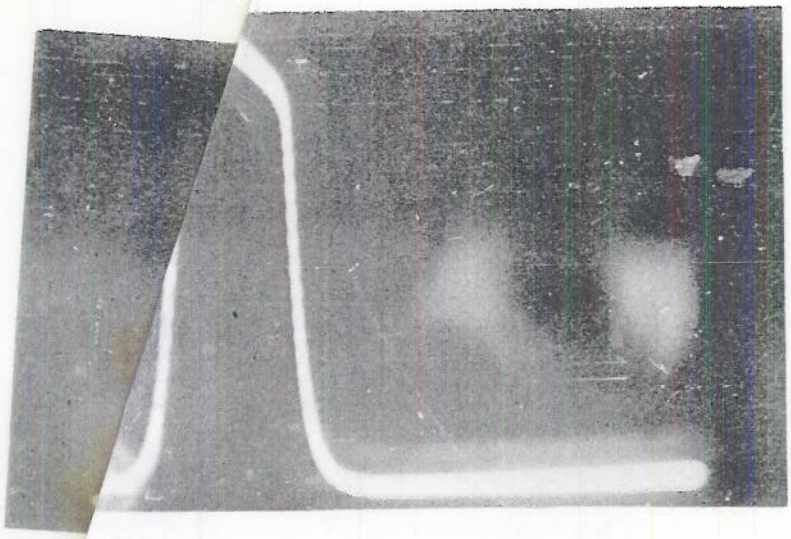
(E)LINEARITY OF SWEEP #2 OF THE MODEL A1 TRANSMITTER TESTING CRO.

(F)LINEARITY OF THE 400 MICRO-SECOND SWEEP OF THE NRL SERVO-CRO.

(G)50 MICRO-SECOND MARKERS ON FAST SWEEP #1 OF THE DAS-1 RECEIVER.

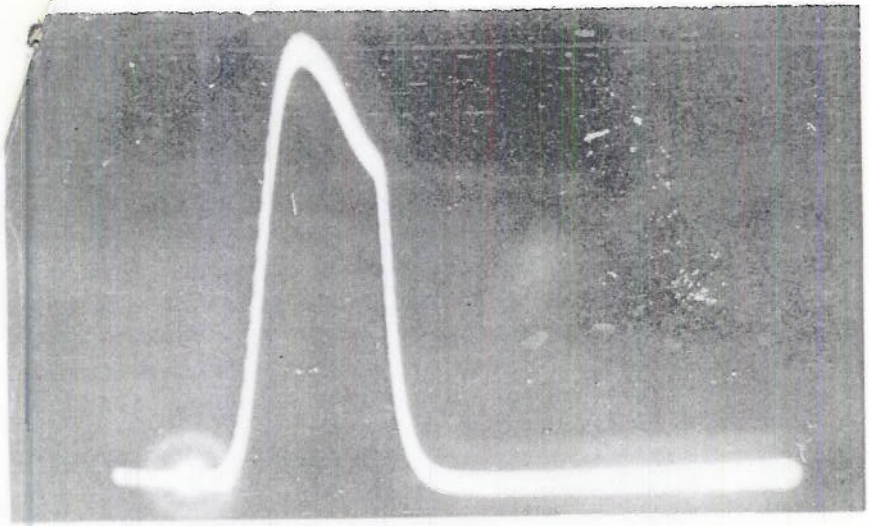
(H)10 MICRO-SECOND MARKERS ON FAST SWEEP #2 OF THE MODEL C TIMER.

APPENDIX PLATE 4



(A) SINGLE PULSE

SYLVANIA MODEL A1 TRANSMITTER TESTING OSCILLOSCOPE
SERIAL #31-SWEEP #2.



(B) DOUBLE PULSE

20,000 MICRO-SECOND INTERVAL BETWEEN PULSES
SYLVANIA MODEL A1 TRANSMITTER TESTING OSCILLOSCOPE
SERIAL #31-SWEEP #2.